Teacher's Manual for

HY DISCOVERIES

The HOW AND WHY ScienceBooks

Frasier, G. W.

A TEACHER'S MANUAL
AND SCIENCE HANDBOOK
to accompany

HOW AND WHY DISCOVERIES
BOOK VI

of the

HOW AND WHY SCIENCE SERIES

including also

A KEY TO THE COMPANION BOOK

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THE HOW AND WHY SCIENCE BOOKS

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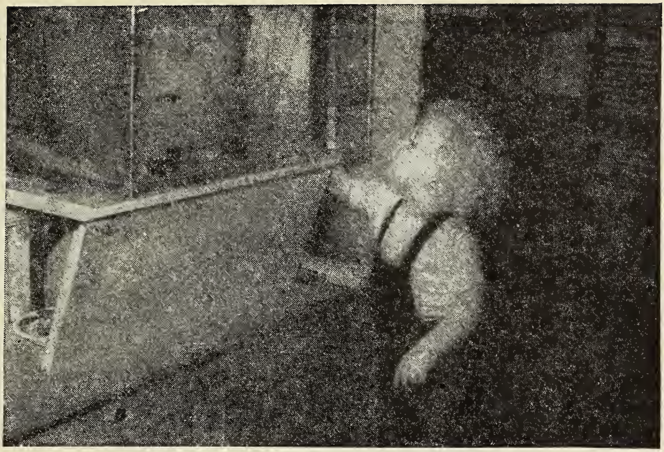


"All knowledge begins in wonder."

ELEMENTARY SCIENCE

THE PHILOSOPHY OF SCIENCE TEACHING

Someone has said, "All knowledge begins in wonder." A child entering school for the first time brings with him spontaneous enthusiasm and interest in the world about him which manifest themselves in an eagerness to relate his experiences. He is full of questions about the caterpillars, frogs, turtles, and other live things that he finds as he plays. He is curious about the weather, the heavenly bodies, and other physical phenomena of his environment. He asks how and why the mechanical devices of his everyday experiences work.

Too often this natural curiosity of the little child is lost instead of being developed during the first few years of school life, because teachers and parents feel their inadequacy to meet the situation. The knowledge required to answer all these questions is so great as to discourage the average adult. When children are curious, they have no respect for the lines of subject matter. One question may fall in the field of biology; the next in physics or chemistry. To

answer all questions completely might well require more knowledge than even a specialist would possess.

However, to teach science to children it is not necessary to be able to answer all their questions. The alert teacher with abundant enthusiasm and curiosity can help them find the answers to many of their own questions. Nowhere will her efforts bring more satisfying results than in the teaching of science.

The philosophy of science teaching differs very little from that of any other subject. It is the subject matter which makes the handling of it more difficult, because teachers are not generally trained for science teaching. The teacher must take into account those things in the child's experience which lie in the field of science. There are many experiences common to children everywhere that may become the foundations of our science work. From these common paths teachers may diverge with the interests of individuals and the groups, and adapt the teaching to the local community or section of the country.

We live in a world that is changing so rapidly that what is grist for the science mill today may become a waste product tomorrow. One day a Byrd explores Antarctica; a Beebe explores the depths of the ocean; or a Piccard penetrates the stratosphere. At such times even first-graders may discuss the stratosphere but to put the stratosphere into a first-grade book, in the light of our present knowledge, would be questionable.

Again, the children we teach are affected by varied environments. Those of the western plains have a whole set of animal concepts not possessed by children of the Atlantic coast. Children in a mining town, children from the country, children from a metropolis—all have experiences which give them different ideas. But through all these experiences the teachers may teach the same scientific principles. For example, hibernation of animals may be taught to a western child by a study of snakes; to a child in the lake region by a study of frogs; to a child somewhere else by the study of clams, crayfish, or some insect.

In science, the teacher needs to remember individual differences. Some children respond more freely to experiences with plants, some to animals, some to physical science. By encouraging children to express themselves freely in the classroom, and to experi-

ment for themselves with the materials found in the science room, the teacher can discover these differences and make effective uses of them.

Above all, to be a successful teacher of science, one must be enthusiastic about the subject, enjoy working with children, and understand the way they think. She must be scientific in her own attitudes and be able to use the problem-solving method of teaching. She does not have to be a specialist in science nor be afraid that she won't know all the answers. She probably won't be able to answer all the questions which the children ask, but even if she can, to do so would spoil the fun for the children. She need not hesitate to say, "I don't know," providing she continues, "but we'll find out together." Science teaching can be a shared experience of teacher and children that has great possibilities for both.

OBJECTIVES FOR TEACHING SCIENCE TO CHILDREN

Science for the grades should not be regarded as a mere accumulation of facts but as a series of experiences with the science materials that are a part of every child's daily life. These experiences stimulate the curiosity of children and if used properly should lead to behavior changes in the children. To accomplish desirable outcomes the teacher should understand the reasons why anyone studies science. These reasons may be called objectives. Scientists differ in the way they state these major objectives, but they agree on their content. Briefly stated, these objectives of elementary science are:

1. To develop an intelligent appreciation of the natural and physical world.
2. To develop scientific attitudes.
3. To help children acquire the scientific method of problem solving.
4. To help children acquire useful science concepts.

By an intelligent interest and appreciation of the world in which he lives, a child is made aware of beauty that goes deeper than

the mere appeal to the senses. Appreciation should grow as knowledge is gained. The person who gets a satisfaction from the color and form of a beautiful butterfly should enjoy it more after seeing its transformation from pupa to adult. The child who, looking intently at a butterfly's chrysalis, exclaimed, "Oh, I can see the wings through the chrysalis skin!" was experiencing appreciation. Children should get a thrill out of their science experiences which will make their lives richer and more enjoyable.

Appreciation should lead to the conservation of wild life. The biological principles of the struggle for existence and survival of the fittest tend toward a balance in nature, unless man upsets the balance. Through experiences with material such as that used in "Insects in the Garden," "Birds in the Orchard," and "Life in the Pond," children may be led to see the relationships of plants and animals. They learn which ones are harmful, and what to do about them, as well as which ones are helpful to man.

The second objective, that concerning scientific attitudes, should run through all science teaching. The child who develops scientific attitudes:

(*a*) Will have a conviction of basic cause-and-effect relationships which will make it impossible for him to believe in superstition or unexplained mysteries.
(*b*) Will have a sensitive curiosity which will lead to making accurate observations, collecting data, and searching for adequate explanations.
(*c*) Will have the habit of delayed response, preventing him from making snap judgments or jumping to conclusions.
(*d*) Will weigh evidence carefully to find out if it is sound, pertinent, and adequate.
(*e*) Will have respect for another's point of view, and be willing to change his point of view in the face of new evidence.

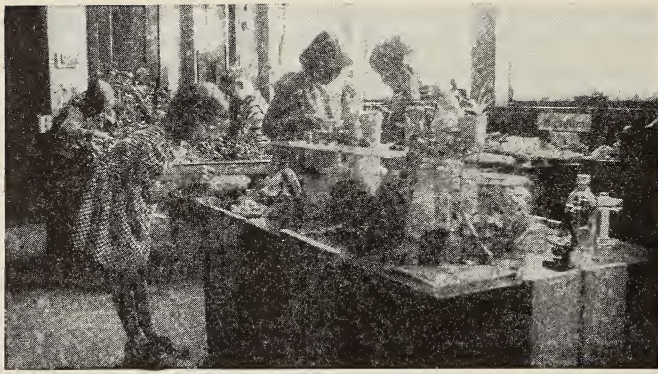
These may sound formidable to the teacher who has had little training in science. She may recognize them as desirable outcomes, yet not have the slightest idea of how to go about teaching them. She need not be frightened, however, because the techniques by which she helps children develop scientific attitudes are

very similar to those she uses to develop social attitudes. The first step is to be able to recognize a *lack* of the attitudes.

For example, a child who says, "My grandmother says the ground hog saw his shadow and he can tell about the weather," has not developed the attitude of looking for a cause. The teacher could help him develop the attitude by saying, "That is interesting. I wonder what makes your grandmother think that," or, "I wonder how the ground hog (woodchuck) knows." The child may answer, "If he sees his shadow on ground-hog day, we'll have six weeks of bad weather." Then the teacher may say, "That may be true, but what do the rest of you think about it?" After a brief discussion she may say, "All of you are just giving ideas. Is that the way scientists (or people who study woodchucks) would settle a question?" The children may suggest watching for woodchucks or discussing the weather on February 2—will the woodchuck see his shadow or not? They may watch the weather for six weeks, recording it and comparing the actual weather with the woodchuck's "prediction." Some child may be bright enough to remark, "It may be cloudy in the fields south of town and the sun may be shining on the north side. The north side couldn't have six weeks of bad weather while the south side is having good weather." The grandmother (who would have resented it had the teacher said, "That idea is not true, Tom,") may become interested in a long-time experiment; but, whether or not there is hope for grandmother, Tom's plastic mind has been affected by six weeks of observing and checking.

Later when Dick insists that horsehairs turn into snakes, Tom will be eager to bring rain water and a horsehair to find out if Dick is right. Bit by bit, these experiences will straighten out Tom's thinking until one day he will say, "I don't believe in superstitions. One day when we were out driving, a black cat ran across the road. Later we had engine trouble, but the trouble was caused because a part had worn out."

Not only is this attitude taught by correcting existing superstitions and misconceptions, but it impels children to look for the causes of all natural phenomena. Numerous opportunities arise every day to develop it. For example, in trying to solve the problem of why food spoils, the teacher may ask, "Where does your



Independent investigations.

mother put food that she wants to keep?" Through discussion someone may say, "Temperature will affect food. When food gets hot, it spoils." In problem solving there are many opportunities to teach scientific attitudes.

The ability to interpret natural phenomena correctly does away with unreasoning fears. The child who understands the cause of thunder, and has demonstrated the sound in a small way by clapping his hands, is not so likely to be afraid of it. Knowing that animals are not likely to sting or bite except in self-defense, he is less susceptible to the fear carried by many people into adult life. The person who has studied about meteors and northern lights doesn't assign mysterious reasons or results to these natural phenomena. The child's understanding of the cause and prevention of disease helps keep him from carelessly exposing himself and others, as in the case of colds. He learns that everything has a cause; that disasters don't just happen, nor, as was once believed, are they visited upon us as punishment.

Curiosity concerning their environment is natural to children, though some have more of it than others. But sensitive curiosity may have to be taught. Children ask many questions to which they really don't expect an answer, nor care for one. Sensitive

curiosity is demonstrated by a perseverance on the part of the child in asking a question, or in independent investigation on his own initiative. Children should be given opportunities to tell of things they observe that stimulate their interest and curiosity. If learning is dependent upon desire to know, then curiosity is a valuable attitude to develop. Some children have it to such a degree that no amount of squelching on the part of adults will stop their investigations. They learn in spite of their teachers. Other timid ones stop asking when they get no satisfactory explanation. The child who persisted in saying, "I *want* to *know* what makes the bubbles in cake," after the teacher had told her it was too hard for her to understand, had unquenchable curiosity.

The ability to make accurate observations and the ability to collect data are outcomes of the attitude of sensitive curiosity. Some techniques which help in the teaching of this attitude are:

(*a*) Making use of the children's suggestions of ways to collect data—for example, when Mary wonders what will happen if a prism is held in a cloud of dust while a sunbeam is striking it, let Mary try the demonstration, using chalk dust.

(*b*) Insisting upon accurate descriptions when a child reports having seen something—for example, when a boy describing an insect the size of a gnat, tells of a yellow stripe around its body, the teacher may say, "Just a minute. How could you see the yellow stripe on an insect no larger than a gnat? Tell just what you saw. If you didn't see the color, don't tell about it."

(*c*) Setting an example of collecting data by asking questions about many points which the children have not mentioned in their descriptions.

(*d*) Insisting upon experimentation or demonstration being directed to the purpose of gaining adequate explanations. Children are likely to become more interested in the working of the apparatus than in the answer to their original question. Then the teacher may say, "Why are we doing this experiment? Is it helping to answer the question? It is an experiment only as long as you are learning. After that it is play."

The attitude of delayed response is developed by insisting on the children's not "jumping to conclusions." The child who says, "I saw a bird. I *think* it was a woodpecker because it was tapping on a tree," or "I *think* the fish died because we didn't put any green stuff in the aquarium like we do at home," or "I'm *not sure,* but I don't think the air does all of the work of holding the plane up," has developed the attitude. The child who says, "I *know* that was a fallen star. There are a lot of them around here," hasn't developed the attitude.

To help develop the attitude of delayed response, the teacher must be on the alert with answers such as:

"We must be careful and not think we have found out something when we really haven't."
"Do you think you should say they are fallen stars? Has anyone proved it?"
"Let's save that question and answer it later. Then we will find out more about it to help us be sure." (And don't forget to do it!)

Having developed the attitudes of basic cause and effect, sensitive curiosity, and delayed response, children are ready for weighing evidence. Children are usually eager to express their ideas without thought as to whether they are pertinent or sound. When the teacher is just starting her science program, she may encourage expression to get things under way. After the ice is broken and the children are no longer inhibited or shy, the teacher has to curb their enthusiasm and direct their thinking.

To do this without breaking their line of reasoning takes skill. The teacher must not be discouraged if her first attempts at developing attitudes result in confusion. She may have to go back to the beginning of the lesson and start over. When this happens, the teacher should take the children into her confidence by smiling and saying, "I guess I got us off on the wrong track. Let's see where we were," or "We're all mixed up. You'll have to help me. What were we trying to find out?" The children will respond to this.

Some ways to help develop this attitude of weighing evidence are to give suggestions like:

"Let's remember not to take too much time with details that don't really have anything to do with our problem."

"Does your question have anything to do with electricity? Have you thought it through?"

"Do you think that we have enough information to answer the question?"

"Should we decide before we know what a scientist has to say about that?"

"Let's keep our minds on one track."

By consulting an authority, the teacher should check often on the accuracy and soundness of the experiments being done. The children should check with their science texts. They should never draw conclusions from one experiment.

A child who has developed this attitude will say things like this: "I think the tooth comes from the upper jaw by the way it curves. If you'll look at a dog's teeth, you'll notice that the upper teeth curve down over the lower teeth. It's hard to tell whether it's the upper tooth of a big bear or the lower tooth of a small bear," or "We haven't read it carefully enough. He forgot to use a marker so I don't think it would be right."

Willingness to change one's opinion in the face of new evidence is the most advanced attitude of all. The person who has it is tolerant, without prejudice and bigotry. If all the children in the world could really be taught this attitude so that it would function, wars would cease. Science has no monopoly on this attitude, but it offers an excellent opportunity for its natural development. In social studies areas, emotions are more likely to be involved. In solving science problems, children can be more objective. The teacher may say:

"There is a sentence on that page that isn't exactly scientific. Scientists have found out more about it since the book was published."

"When one has the floor, let's remember that others want to talk also, and not take too much time."

"Don't laugh. I'm not surprised that he's mixed up. Grown folks get mixed up, too."

"Do we laugh at people who have ideas?"

"Let John have his chance. Let's listen to what he has to say."
"I think he has an idea, but it just isn't very clear."
"Evidently there are three people who do not agree."
"Jane listened to you; now it is her turn."

Allow every child an opportunity to tell one thing he has observed or learned from an experiment. Give careful consideration to every child's serious question or attempt to explain something. If the teacher respects children as individuals, respects the importance of their problems, and is willing to change her own mind when she sees that she is wrong, it will help in teaching this attitude.

The child who has this attitude will say, "I don't quite agree with her because I think there is a change in the temperature of the land," or "I thought the candle wick burned, but now I know that it is the gas that burns."

Children often have pretty definite ideas about their experiences and are not willing to change those ideas. For example, many people use widely advertised products in their homes without investigating their true value. One science group made a study of some of these products and discovered that the advertising was misleading. The children in the group were learning to evaluate and test statements in the light of evidence.

Willingness to change opinion, to search for the whole truth, and to base judgment on fact are all closely related and may be developed together. They may all result from a comparison of experimental data or accurate observations.

A child may have formed some incorrect idea that he has heard or read in a book. For example, a child insisted that "beavers carry mud on their tails" because he had read it in a children's storybook. The other children challenged his statement. The teacher asked how they could know whether or not the statement was correct. The children said to ask a scientist or look it up in several books written by scientists who had studied beavers. When this was done, the child who had made the statement saw that his idea was wrong. He also realized that he could not believe everything he read.

Although the information and skills needed by teachers for teaching problem solving to children are presented at considerable length on pages 11–18 in each of the Primary Manuals for The How and Why Science Series, an examination of an actual lesson may be of value here.

One of the most difficult techniques for a teacher to master is that of motivation or "problem setting." The ideal way for problems to arise is through spontaneous questions from the children, but this seldom happens until children are well into the science program. Often the teacher must arouse interest and bring to the surface the questions which may be in a child's mind. The skillful teacher can do this in such a natural way that it is not superimposing a topic for study but guiding the thinking of the children. The secret of gaining whole-hearted cooperation in the solution of a problem often lies in this technique. An example of a motivation and exploration period followed by the techniques used in solving a fourth-grade problem will illustrate this.

These fourth-grade children had been studying magnets and were ready for some work with electricity. The teacher asked the children to think of ways in which electricity is important to them. She asked, "How many things that use electricity do you have in your homes?" As the children responded, the list was written on the blackboard. The list stimulated some discussion. Sammy said, "When you rub your feet on the rug you get electricity." Some of the children said that they didn't think it was electricity that he was talking about. Jane said, "You can't run anything with it." Had Jane not made this comment the teacher might have asked, "Can you run a sweeper with it, Sammy?"

Sammy defended his statement by saying that he sometimes got a shock and saw a blue spark. Several children had explanations for these happenings so at the peak of the discussion the teacher asked, "Are you being scientific? You are all giving your opinions but I wonder if that is the way a scientist would settle a question." Since by this time all of the class was interested and ready to state problems, these were listed and written on the board. Some of the questions were:

1. What makes a shock and a spark when you walk across a rug and touch something like a doorknob?
2. Why does the radio go off when you drive under a bridge?
3. What causes static on the radio?
4. What makes telephone wires hum?
5. How does water make electricity?
6. How does electricity make a light go on and off?

The class read the problems and decided to start with:

PROBLEM: What causes the shock when you walk across a rug and touch something?

ANALYSIS:

The teacher directed the analysis of the problem with questions like: "Do you always get a shock when you walk across the floor?" Several children were allowed to demonstrate. Nothing happened. Reasons were suggested, such as: there was no rug on the floor; they didn't scrape their feet. Bob said that he had walked across a bare floor and "made" electricity and that he could do it again. He was asked to try it and was puzzled when he got no results. Since it was a rainy day the teacher suspected that the moisture in the air was responsible, but she merely said, "It is time for us to end our science lesson today. Why don't all of you try the experiment at home tonight on a rug?"

The next day the rain had ceased and the air was crisp and cool. The children had repeated the experiment at home and were ready to report results. Some had managed to get a slight shock, some had not. However, they were ready to give some possible solutions to the problem.

POSSIBLE SOLUTIONS:

Perhaps the temperature causes the shock when you rub your feet very hard on the rug.

Perhaps you and the metal you touch act as two poles which have an attraction for each other. (This idea grew out of their experiences with magnets.)

Perhaps the shock is caused by friction.

As each of these possible answers to the problem was given, it

was discussed to make sure that the child wasn't repeating words he had heard, without understanding them. For example, the teacher asked, "Do you know what friction means?" The child who had used the word said, "Oh yes. It means something strange and wonderful—you know, stranger than friction."

Obviously the word needed clarification. Other answers were: "I think friction is a kind of electricity." "I think friction is like a spark or shock." Finally a child said, "I looked up friction in the dictionary and it said 'rubbing two things together.' "

These answers are given to impress the importance of word meanings. Teachers know that it is essential for children to connect the correct concept with a printed symbol when reading. In a science class, unless all members have the same concept of a word used in discussion, accurate conclusions cannot be drawn. The illustration of the child who confused friction with fiction shows how he could give a seemingly correct answer and still have an incorrect idea.

Having given possible solutions, the children discussed ways of testing them. They thought of experimenting and reading. At this point the teacher remarked that she knew of some experiments in THE HOW AND WHY CLUB which might help.

SOLUTION:

The children read page 315 and the first three paragraphs of page 316 of THE HOW AND WHY CLUB. The experiment suggested others to them and they did the following:

1. Rubbed a pen on woolen clothing and held it near bits of paper.
2. Repeated the experiment with various objects, such as combs, pencils, and rulers.
3. Rubbed pieces of paper on their desks.
4. The teacher suggested the following:

A piece of glass was placed between two books so that the center of the glass was about one half inch from the table. Bits of paper were scattered on the table below the glass. The top surface of the glass was rubbed briskly but lightly with a piece of silk. (If it is rubbed too hard, the experiment may not work.)

Results:

Some exclaimed, "The paper sticks to the desk!"

Tom said, "I rubbed two pieces of paper together and they stuck together. When I pulled them apart they crackled."

Ruth said, "I'm not sure, but maybe when you rub something fast and hard it gets hot. Is that friction?"

Jack asked, "When you rub a balloon on the floor and stick it against the wall, what makes it stay?"

These illustrate the thinking done by children when they are allowed to experiment freely and to express their reactions.

During this period the teacher listened, counterquestioned, and helped children who were having difficulties. When she saw that the activity had accomplished its purpose, she said, "May I have your attention, please?" Then she asked, "What did you find out?" Every child who had something to say was allowed to report on his results before the teacher asked for a summary by saying, "Can someone put everything you have said into a few good sentences?"

These were given and written on the blackboard:

What Happened:

When we rubbed a pen or comb on woolen cloth, it picked up pieces of paper.

When a pencil was rubbed on wool, it did not pick up the paper.

When a piece of paper was rubbed against a desk or blackboard, the paper crackled when it was pulled away.

When a piece of glass was rubbed with silk, the pieces of paper under the glass jumped around. Some of them stuck to the glass.

The teacher asked what they now thought about their possible answers. The class decided that the last one was best. The teacher then suggested that they re-read together pages 315 and 316 of The How and Why Club. (Reading orally clears up any mistaken ideas some children may have received as they read silently.)

Following the reading, the discussion brought out the following conclusions:

Mary said, "I think that friction when you walk across the rug causes you to unconsciously pick up electricity."

Shirley said, "I'm pretty sure it is friction because it said so in the book."

Other children stated similar ideas. These were written in their notebooks:

WHAT WE LEARNED:

> When you rub your feet on a rug, electricity is generated by friction. The electricity travels through your body and attracts electricity from whatever you touch. The electricity gives you a little shock.

Had this been an older group of children, each one would have been allowed to write the conclusion in his own words but since these children were just learning to write the steps in problem solving, they gave their ideas orally, then copied the group answer from the blackboard.

A discussion followed of why there is more evidence of static electricity on a cold dry day than on a warm damp one. This is due to the fact that water is an excellent conductor of electricity and the droplets in the air conduct it away as fast as it is generated.

Teachers may contend that this procedure is too time consuming, that the same goal may be accomplished more quickly by reading the text. The author believes that the increased growth in a child's ability to think for himself and the added interest repay the extra time. Over a period of years time is actually saved, since concepts once gained are not forgotten.

The author has taught the same children science from the first grade through the sixth and been amazed to find how much knowledge they accumulated in that time. Very seldom did a concept have to be re-taught. When it was reviewed, though some children seemed not to remember, the others did and it was recalled quickly by the whole group. When no one remembered, the teacher knew that the children had not developed the understanding of the concept in the first place, perhaps because it was too difficult for the age level or because it was poorly presented. More important, through the methods used, the children were independent in their thinking and enthusiastic in their attitudes toward science material.

The following lessons illustrate other types of activities used in solving science problems.

Problem Solving Lesson—Grade 5

Using observation and experimentation

The children knew that a young porcupine had been brought to the science room before they came to class, so all eyes were turned toward the cage and there was a buzz of private discussions and occasional distinguishable tones of disagreement as the children found their places.

Teacher: "What is in the cage?"

Child: "A porcupine."

For a few minutes the children told of experiences they or their friends had had with porcupines. Conflicting points of view brought up the question of how the quills were released from the porcupine's body.

I Problem: How do quills get out of the porcupine?

II Analysis:

Question: I have two quills from this porcupine. How do you suppose they got out of his body?

Answers:

1. Maybe the quills were loose and when you got real close he raised them up and they stuck fast to something.
2. Maybe he shot them out.

III Hypotheses:

1. Perhaps the quills stick fast to anything they touch.
2. Perhaps the porcupine shoots out his quills.

The first two possible solutions were suggested and tested. Neither solved the problem, so teacher and pupils discussed the scientific method to be used when hypotheses first suggested fail to solve a problem.

They decided some additional possible answers must be suggested. The teacher helped the children in their thinking by asking them to think of experiences dogs have with porcupines. From an account of a dog's chasing a porcupine and snapping at it the children formed these hypotheses:

3. Maybe it takes pressure for the quills to stick fast.
4. Perhaps the porcupine has to be frightened before the quills will stick fast.

IV SOLUTION:

A. Gathering Data:

Materials used: Shingle with strip of cloth wrapped around it near one end, rubber gloves, stick for prod.

Teacher: Have you any suggestions as to how we may solve the problem?

Children: 1. Read.
2. Ask someone who knows.
3. Experiment (try something).

Experiments:

1. A child touched the porcupine with a stick.
2. The teacher touched the porcupine with rubber gloves on her hands.
3. The children watched the porcupine when he was frightened by noise and a prod.
4. A boy pressed the stick wrapped with cloth against the porcupine's back.

B. Results:

1–2. The quills did not stick to the board or the glove.
3. The porcupine did not shoot any quills.
4. Quills stuck to the stick wrapped with cloth.

V CONCLUSION:

Quills stick fast to a soft object if pressure is used.

The teacher wrote each step of the problem solving on the blackboard as it was given under the headings: Problem, Suggested Answers, What We Did, What Happened, and Conclusion. As a number of the children were not familiar with the problem-solving method, the teacher asked that each copy the material from the board for their own notebooks.

To confirm their conclusions, the children read page 85 of HOW AND WHY EXPERIMENTS.

Problem Solving Lesson—Grade 6

I Problem: Why are sandstones different colors?

II Analysis:

Teacher's question: "What colors are sandstones?"
Children's answer: "Sandstones are mostly white and red, but I don't know why."

III Hypotheses:

1. Perhaps the sun has something to do with the colors.
2. Perhaps the sand that the rock was made of was different colors.
3. Perhaps the color was caused by what sticks it together.

IV Solution:

A. First Experiment
  1. Gathering data
    a. The children put different kinds of soil and crushed rock into jars of water, shook them well, and placed them on the window sill to settle.
      (1) Jimmy ground red sandstone and put it into his jar.
      (2) Gertrude used white sandstone.
    b. The next day the children brought different colored sandstones which they had crushed at home.
  2. Results
    a. The next day the children looked at the jars of crushed rock and noticed several things about them.
      (1) The material appeared in layers.
        (*a*) The coarser material was on the bottom.
        (*b*) The finer, sticky material was on top.
        (*c*) There was loose material on top of the water.
      (2) The material seemed to be different colors in some places. Each child showed his own experiment to the class and pointed out what he noticed about it. The class discussed why sandstone might be different colors.

B. Second Activity

1. Gathering data

    a. The next day Walter brought a rock which his grandfather said contained iron. The class discussed possible reasons why the rock might contain iron.

2. Results

    a. Walter brought out his rock that had been standing in water and the class looked at it and discussed the change.

    (1) Some of the rock had come off and made orange-colored sediment on the bottom of the pan.

    (2) The question, "What is rust?" arose. Many of the children gave examples of how iron had been left out in the rain and had rusted, or of different implements that had rusted.

    (3) The teacher then asked, "Does anyone see any connection between the color of rocks and rust?" One child answered, "Sandstone has some iron in it and it rusts. That's what makes it colored."

V CONCLUSION:

A. The cement sticking the sandstone together makes it colored.

1. The cement part may have come from iron ore.
2. The cement may be made of clay which is found in different colors.
3. When we looked through the microscope the sandstone didn't have any color, therefore it must be the cement part that gives the color.

The children read pages 163 and 164 in HOW AND WHY DISCOVERIES to confirm their conclusions.

Problem Solving Lesson

Written by a fifth grade child

Problem: What makes the sky blue?

Possible Answers:

The sun hitting the moisture in the air may make the sky blue.
The sun shining on the dust in the air may make the sky blue.
Perhaps there is so much air that when we look through it the sky looks blue.
Perhaps it is because the sky is so far away.

What We Did:

Gilbert took a paper and put it in a sunbeam. He followed the beam with the paper. He put chalk dust in the sunbeam.
We put a prism in a sunbeam.

What Happened:

We could see the sunbeam shining on the paper.
We could see the sunbeam reflected on the dust.
The sunbeam going through the prism split into colors.

What We Learned:

The dust in the air acts as little prisms and splits the light into colors. Usually in the middle of the day only the blue gets to our eyes. The other colors shoot off into space. At different times different colors show, but most of the time it shows blue.

HOW TO DO AN EXPERIMENT

The purpose of an experiment is to help in the solution of a problem. To be a real experiment it should originate with the persons who raise the question and be carried out by them. Since children do not often have the background to do this, they need help in directing their thinking. However, an activity suggested by the book or the teacher should help solve a problem. Too frequently teachers use a spectacular demonstration merely to get or keep the attention of the children and label it an experiment. While such an activity may be legitimately used once in a while it should not be called an experiment. It is a motivating activity.

If children have a problem to be solved they may learn the experimental technique no matter how simple the problem. Allow them to perform original experiments.

The first step in scientific method is the defining of the problem. The teacher should make sure that the children know what their problem is. It may be as simple as, "Why does a piece of wood float?"—a problem which may arise in any grade.

The next step is the analysis of the problem. The teacher must lead in this analysis by her questioning. She may ask, "How do you know that wood floats?" "What other things float?" "Can you think of ways we might find out why things float?" The children may suggest trying to float several things in water.

The next step is assembling of the materials needed for the experiment. In this case these are a tub of water, various articles such as a sponge, a rock, a cork, some wood, and a balloon. The children should suggest what they think is going to happen before they put the various articles into water. As they work the children will discover that the sponge floats until the holes are filled with water. As this happens air will escape into the water. The balloon will float unless the air is replaced with water. If the balloon is squeezed under water air bubbles will come to the surface as the balloon fills with water. The teacher must be sure that the children observe *carefully* and report *accurately* what happens. She must be sure to give them enough experiences upon which to base conclusions. By having several groups doing the same experiment the children will learn to check their results with those of others. The final check should be with an authority.

Teachers who are helping children to perform experiments will find that careful planning will eliminate confusion. In her plan the following steps will produce better results.

1. Write down the problem to be solved.
2. List the activities to be used in its solution.
3. Select the first experiment to be done.
4. List the materials needed.
5. Note any precautions to be used such as having a metal tray under a burner, or having soda or ammonia ready to counteract acid burns.

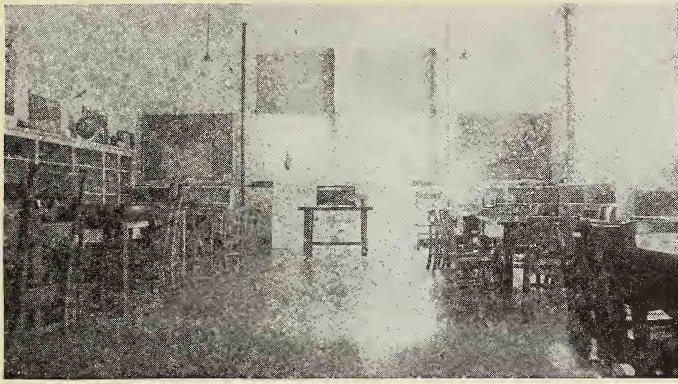
6. List the steps of the experiment in order of procedure.
7. Do the experiment yourself to familiarize yourself with the apparatus and procedure.
8. Jot down exactly how the children will be directed.

To avoid accidents the children should know and use safety measures. Before doing an experiment involving any danger, the children should discuss it and decide what to do in case there is an accident. A first aid kit should always be at hand and any accident used to teach first aid. The teacher should always try to anticipate anything which might happen and to teach the children how to avoid accidents.

Some of the common causes of accidents are careless handling of fire, acids, glassware, hot liquids, and poisonous chemicals. Even experienced teachers may become so interested in the experiment that they fail to notice such possible dangers as a child with long hair bending over a flame or a piece of paper placed too close to a fire. Acids should be handled carefully. The cork from an acid bottle should be held between the fingers with the acid-coated end away from the hand while the acid is being used and replaced in the bottle when one is through using it. Avoid touching clothing or skin with the end of the cork that has been in the bottle. Do not allow children to come too near liquids that are being heated because boiling liquids may sputter, splatter, and pop into their faces. Children should be taught to handle glassware with caution, to avoid being cut.

Warn children to keep fingers and other objects out of their mouths as this may be a means of carrying poisons to their mouths.

In some school systems there are rules against using fire or chemicals in the classroom. In these places teachers will have to substitute an electric plate for heat and use harmless substances such as vinegar and soda instead of hydrochloric acid and calcium carbonate. In most cases it is wiser to use simple chemicals anyway. Too often children have the idea that chemicals and chemical change are confined to the laboratory and do not realize that chemicals are common in their everyday lives.



A science room.

SCIENCE ACTIVITIES COMMON TO ALL GRADES

THE EQUIPMENT OF THE SCIENCE ROOM

Although it isn't absolutely necessary to have a separate science room for elementary science, it is often desirable. The room need not contain elaborate or expensive furniture and equipment. Many times it will be advisable to carry out the science activities in the children's own home rooms. Many schools have a science room where equipment may be stored and where live plants and animals may be kept.

The ideal room is located on a sunny side of the building with plenty of light for growing things. If the room is planned before the building is constructed a small conservatory may be provided in a large bay window with glass doors between it and the main room. Thus the temperature may be kept right for any living things with which the children may experiment.

An ordinary classroom may be adapted to the needs of a science class with very little expense. Water, gas, and electric outlets should be provided if possible. Shelves for books, specimens, and

Shelves provide places for permanent collections.

plants may be installed under windows and cabinets. A closet and built-in cabinets are needed for care of equipment. Bulletin boards and a blackboard are indispensable if classes are to be held in the room. Movable tables and chairs are preferable to desks. The tables should have a hard finish that is washable and not easily marred. Linoleum or newspapers may be used on ordinary tables to protect the tops.

Much of the equipment of the room may be made by the teacher and children with the help of the shop or manual arts teacher. Aquaria of varying sizes may be made or purchased at little expense. See the suggestions in another part of this manual for making and balancing aquaria.

Cages for small animals may be easily made of wire netting and crates. Insect cages and brooding cages are simple to construct.

Some source of heat is necessary such as gas, electricity, or an alcohol lamp. If you have gas, you will need a bunsen burner, a tripod, some wire screening, and a metal tray on which to work.

Jars and bottles of various sizes may be collected to use in place of the flasks, beakers, and test tubes shown in the texts. Pint salad dressing jars are a very useful size.

Coffee cans may be used for many experiments. Waxed paper cups are also useful pieces of equipment.

A compound microscope and a dozen reading glasses 2½″ or 3″ in diameter should be available.

A file to hold pictures and other bulletin board material is a great help. A substitute may be made of an orange crate.

Reference books, science texts, magazines, and pictures should be kept where the children can obtain them easily.

Since one of the habits we wish to have children gain is caring for equipment, dishpans, soap, and other materials should be provided for keeping things clean. Laboratory assistants may be appointed at intervals to help in preparing for and cleaning up after experiments and demonstrations.

A set of Audubon charts, a globe, a good map of the western hemisphere, and a sky chart all help in answering questions. A lantern and slides will also help.

Some dry cells, insulated copper wires, and magnets will be needed for any work with electricity or magnetism. Old switches, fuses, sockets, and other illustrative materials are easily obtained.

The combined ingenuity of the teacher and children should make it possible to collect the materials suggested in the activities or to find substitutes. While some schools have excellent equipment and well planned rooms in which science is taught, equally good teaching is being done in other schools without such advantages. Since science on the elementary level should grow out of the children's own experiences, the very materials that stimulate the questions will provide the answers. The really necessary factors are an alert, interested teacher, normal inquisitive children, and the environment. Below is a list of materials which may be collected from the environment.

Glassware

Salad dressing jars—straight sided and flask shaped.
Fruit jars.
Vinegar and pickle bottles.
Tall, straight bottles.
Different sized pieces of glass cut from broken windowpanes and windshield glass.
Tumblers.
Glass or china saucers.
Milk bottles.
Small-necked bottles.
Lamp chimneys.
Glass tubing.
Pipettes (medicine droppers).

Miscellaneous Equipment

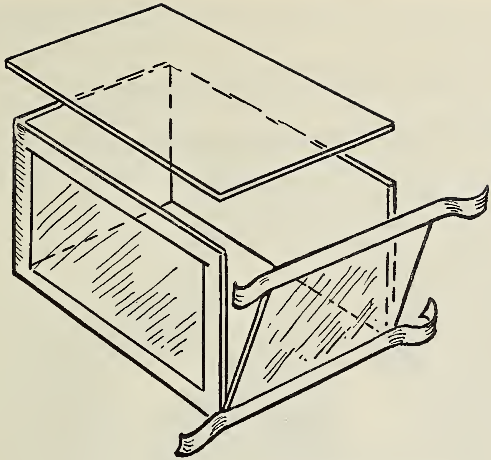
Flower pots.
Tin cups.
Spoons of different sizes.
Knives such as old butcher, paring, and case knives.
Pans that have been discarded to be used to carry snow, heat water, etc.
Pieces of wire screening, scraps of sheet metal, such as copper, zinc, and iron.
Toy balloons.
Cellophane.
Rubber bands.
Scissors.
Scraps of rubber sheeting.
Old balls of various sizes.
Cardboard boxes and cartons.
Chalk and other wooden boxes.
Wire—steel and copper.
Flashlight.
Dry cells.
Empty syrup and oil cans.
Corks of different sizes.
Dry cells.
Hard rubber comb, pen, or other object to use for static electricity.
Simple machines, such as egg beaters, can opener, and hammer.
Nails, tacks, screws, and bolts.

Supplies

Matches and candles.
Starch, sugar, salt, soda.
Vinegar.
Ammonia.
Rubbing alcohol.
Lime for limewater.
Iodine.
Litmus paper, red and blue.
HCl.
Charcoal.

HOW TO MAKE A TERRARIUM

A simple terrarium has so many uses that it is well to know how to make one. First, it is necessary to have a container. A glass jar of any kind will do, but one with straight sides is better than a round one. A glass box may be easily made from six pieces of window glass cut to the desired size. These may be fastened together with one-inch adhesive tape or black *passe partout* tape. Rub the tape until it sticks firmly to the glass. The lid may be fastened so that it is hinged, or merely laid across the top. All edges should be bound with tape to prevent cut fingers. A further precaution is to have the edges of the glass beveled at the time it is being cut.



A terrarium made from glass and adhesive tape.

A wooden base instead of a glass one may be used for the box. If wood is used, it should be so cut that at least one inch will project from around the glass at the bottom. The board may be treated with melted paraffin to make it resistant to water. A half-inch furrow should be sawed in the wooden base, the dimensions of the glass, and made wide enough to take the glass. The glass sides can be more firmly secured in the furrow by means of aquarium cement or putty. Adhesive tape may be put around the top to make smooth edges.

Having a container, start making the terrarium by putting a layer of gravel in the bottom, to provide drainage. Small pieces of charcoal will help keep it sweet. On top of the gravel put soil of the kind found where the plants grow which are to be used in the terrarium. For example, moss and ferns come from the woods. Use woods soil, or leaf mold, for a woods terrarium. Use garden loam for a garden terrarium. Use sand for a desert terrarium.

In the soil plant the moss, ferns, or other plants you wish to use. If you are going to put plant-eating animals into the terrarium, some of these food plants should be planted. For example, if

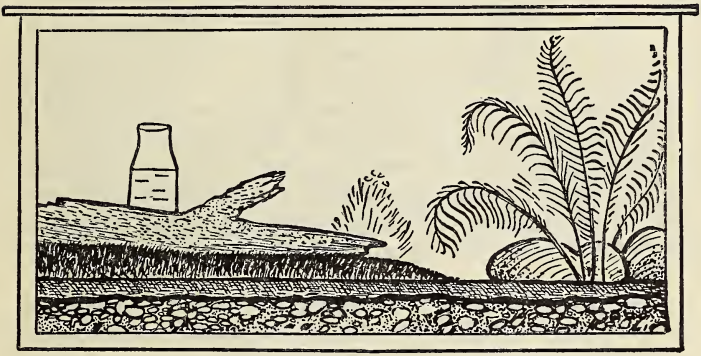
Making a terrarium for a garter snake.

making a home for grasshoppers, plant corn or oats and let it sprout before putting in the insects. For toads, use garden soil, a dish of water sunk into it, with perhaps some stones and a little grass. The toad will bury itself in the soil. Salamanders like moist moss and pieces of decaying wood under which to bury themselves. Lizards and horned toads will bury themselves in the sand of a desert terrarium.

The terrarium should be kept out of strong sunlight and in a place that is not too warm. It should be sprinkled with water when first made, if it has plants in it. After that it should be sprinkled only when the cover gets dry on the underside. Water should be kept in a dish if there are animals in the terrarium. Snakes go into water, and a tall container like a pint milk bottle or pickle jar of water will make them comfortable. A low dish is better for turtles and toads. This can be placed in one end of the

terrarium and stones and soil built up around it to the level of the top of the dish.

A single terrarium should not contain a large variety of animals. Since boxes of glass and adhesive tape are practical and inexpensive, it is better to have several, each one containing a different kind of animal. Gallon coffee jars make good containers.



A woods terrarium.

The food of frogs and toads in the wild state consists of insects, worms, caterpillars, snails, and slugs. They also eat flies, mosquitoes, and gnats. These can be easily provided, but they should always be alive. Frogs and toads will not touch dead worms or insects. They will starve in a terrarium if they have no live food to eat. A fly trap can be made and once a day the flies released from the trap into the terrarium. When there are insects out of doors, they may be caught by sweeping the grass with an insect net. In winter when flies are scarce, meal worms (the larvae of beetles), which can be cultivated in bran flour, may be substituted.

Newts and salamanders can be fed on bits of raw meat, fish, oysters, scrambled eggs, worms, or insects. Land turtles are plant-eaters, using tender plants and berries for food. Water turtles are meat-eaters, using earthworms, insects, crayfish, and small fish for food. Mud turtles eat under water. Horned toads eat living insects. Garter snakes eat earthworms, insects, frogs,

salamanders, and toads. Snails are vegetarians; lettuce is a good food for them.

Care should be taken that an excess of uneaten food does not remain in a terrarium. Terrariums should be kept clean so that the captive animals may live in healthful conditions.

HOW TO MAKE AN AQUARIUM

Almost any container that holds water may be used for an aquarium, but a straight-sided one is best. The globe-shaped ones afford too little water surface for the absorption of air and they distort the shape of objects inside the aquarium.

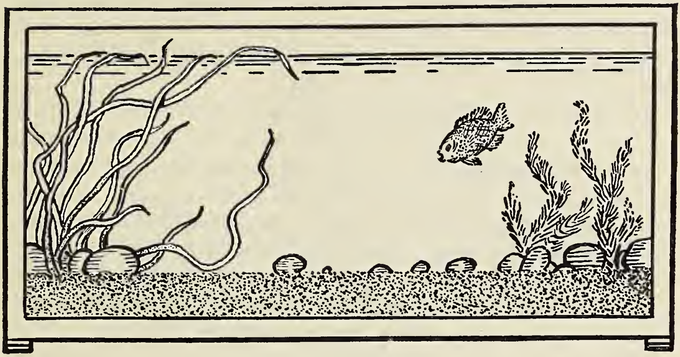
The container must be very clean, and the sand must be thoroughly washed. Sand may be washed by running a stream of water into the pan of sand until the water runs out clean. If the sand is then baked in an oven, any bacteria or mold spores will be killed.

Enough sand should be put into the bottom of the aquarium to insure a good root-hold for the plants. Elodea, eelgrass, and water milfoil are all good aquarium plants and are common in most of our fresh-water lakes and streams. These are satisfactory for summer aquariums but they do not always survive the winter. There are many inexpensive tropical water plants which can be used. Such varieties as Valisneria, Cobomba, Myophilum, and Sagittarium are commonly obtainable. It is believed that Valisneria is the best oxygenating plant. This is a grasslike plant which grows very quickly. Duckweed is a small leaflife plant that is often found floating on ponds. It is attractive in an aquarium, though it doesn't help to supply much oxygen.

The plants should be planted in the sand, then anchored with stones. Water can be poured into the aquarium without disturbing the plants by putting a piece of paper on the sand and pouring the water on the paper, or a dish may be placed on the sand into which the water can be poured.

Clean pond, lake, or rain water is best for an aquarium because it contains minute organisms that may later feed the animals. If tap water must be used, allow it to stand several days before putting it into the aquarium. This allows any lime that might spoil

the sides of the aquarium to be deposited and frees the water from any chlorine that has been added for purification. After adding the water, allow the plants time to become rooted before putting



A simple aquarium.

in the fish or tadpoles. Otherwise the animals may pull up the plants.

One rule for the number of fish in an aquarium is one three-inch fish to a gallon of water. Another rule is an inch of fish for each 20 square inches of water surface at the top. Most people are inclined to put more fish into an aquarium than the amount of water justifies.

Any kind of aquarium fish such as goldfish or tropical fish may be put into an aquarium. However, tropical fish are more difficult to keep than goldfish, and require more attention. The water temperature must be kept above 65° for tropicals, and the feeding must be more regular.

Of the tropical fish, guppies, swordtails, and paradise fish survive well and they have interesting habits. Guppies and swordtails are livebearers. Under favorable conditions, guppies reproduce every six weeks. The bubble-nests of the paradise fish are interesting. Tropical fish and goldfish should not be put together in an aquarium as tropical fish often kill the goldfish. Also the fighting paradise fish must be kept away from other tropical fish.

Some wild fish will survive in an aquarium and they make in-

teresting pets. Small sunfish, bluegills, and bullheads are examples.

Snails should be put into the aquarium to act as scavengers. They help keep the sides of the aquarium clean. Tadpoles will serve the same purpose. Clams also help keep the water clean. If water turtles and small frogs are put into an aquarium, they should be provided with flat pieces of wood onto which they can crawl and get out of the water for air.

The first rule in the feeding of fish is not to overfeed. Only a small amount of food should be given, or as much as will be consumed at that feeding. Food not eaten at once falls to the bottom of the container, sours, and makes the water impure. Goldfish can be fed as seldom as once a week. They should not be fed more than three times a week. Tropical fish should be fed three times weekly. A long glass tube may be used to remove bits of uneaten food. Place the tube straight down over the particle, close the upper end of the tube with a finger, and lift out.

Oatmeal (cooked), boiled white of egg, cream of wheat (cooked), liver (cooked), beef (cooked or raw), chopped earthworms, and flies are good food for both goldfish and tropicals. These foods are better than artificial food. Wild fish can usually be fed earthworms or chopped raw beef. They will also eat live insects placed on the surface of the water.

If the aquarium is balanced, the animals and plants will look healthy and the water will be clear. Cloudy or milky water is probably due to the spoiling of uneaten food, or to decaying plants. This water is bad for fish. Immediately remove the fish and clean the aquarium and replenish with fresh water. In changing fish from one container to another, keep water temperatures the same. Fish cannot stand sudden changes of temperature. Be sure also that tap water has been properly conditioned to remove chlorine. Allow it to stand for twenty-four hours before putting it into the aquarium.

Fish should be handled with a small net or lifted out in a dish of water. Grasping them with the hands is likely to break the film over the scales and permit fungus to get started. If a fish is diseased, remove it at once and put it into a solution of salt water, in proportions of one teaspoon of salt to a quart of water. It may remain in the solution for a period of several hours. Then put it

into a container of fresh water. Repeat the treatment every day until the fish is well.

The children will get much pleasure and profit from their management of both terraria and aquaria. There are many interesting aquarium books and magazines on the market to which they can turn for lists of animals and plants and for notes on feeding. Also in recent years there has been much interest in amateur tropical fish raising and many of the children may come from homes where there is a tropical fish enthusiast.

HOW TO CARE FOR CATERPILLARS

Some caterpillars spin cocoons, some form chrysalids, some go into the ground to pupate, some spend the winter hibernating in the larval stage. In discussing them with the children, suggest that since the caterpillars they find may not be ready to pupate, they must be sure to bring in some of the leaves on which they find the larvae. Then you will know what to feed them. Caterpillars will leave food and hunt a suitable place when they are ready to pupate. Polyphemus caterpillars may be put into a glass jar that has some twigs with leaves on them. A piece of glass may be laid over the top of the jar. This prevents escape of the caterpillar and also helps keep the leaves fresh. If the caterpillar is still hungry it will eat the leaves. The jar should be cleaned each day and fresh leaves put into it. When the caterpillar is ready to spin, it will use the twigs and sides of the jar as its foundation and spin leaves into its cocoon. When the cocoon is finished, it may be removed from the jar and put into a cool place until spring. Jar and all may be put away. If it is kept in a dry place, the cocoon should be dipped in water once in a while.

Caterpillars like the tomato sphinx (tomato worm) go into the ground to pupate. There should be some garden soil in the bottom of the jar for them. A flower pot with a cylinder of wire screening over it is good, also. Some Woolly Bears hibernate in the larval stage so a terrarium with some dead leaves and pieces of bark makes a good home for them. They will spin in the spring. Some Woolly Bears spin in the autumn.

The Monarch or milkweed caterpillar forms a chrysalis. If the children bring any Monarch caterpillars in, put them into a jar

with milkweed leaves. When ready to pupate, they will spin pads of silk on the underside of a jar lid, leaf, or twig, then hang from it and shed the larval skin, leaving the green chrysalis. Since the caterpillars that form chrysalids in the autumn soon emerge, they may be left in the room for the children to watch. Chrysalids of butterflies that emerge in the spring may be cared for in the same way as the cocoons.

Fruit and salad dressing jars are just as good as more elaborate equipment. The main things to keep in mind are to have fresh leaves of the right kind which are kept from drying too quickly but are not wet, and not to have too much heat. After pupae are formed, they should be placed in a cool place, not moist enough to mold, but not dry enough to kill the pupae. Cleanliness in their care is important, as many caterpillars are susceptible to disease. Also when handling caterpillars, be careful not to bruise them. It is better to let them crawl onto a twig and then move the twig, than to pick them up with your hands.

OTHER ANIMALS IN THE SCIENCE ROOM

The extent to which it may be desirable to keep animals in a schoolroom depends upon the size and facilities of the room, the interests of the children, and the kinds of animals you wish to keep. While some plants and animals if properly cared for are sure to make a room more interesting, we mustn't lost sight of the fact that the children are the most important occupants of the room. If having other animals makes the room less attractive or comfortable for the children, you should either do without the other animals, or choose animals that are easily kept in captivity and cared for.

Directions for the care of aquarium and terrarium animals have already been given. All these cold-blooded animals are clean in their habits and have little or no odor about them.

Small mammals such as rats, mice, guinea pigs, and rabbits may be kept in cages in the room if the cages are kept clean. Cages with removable metal bottoms are more easily cleaned than wooden ones. A cage may be made of an orange crate with a galvanized iron tray made to slide in the bottom of the box. One-

Observing a turtle.

half-inch mesh galvanized wire should be fastened to the open side and a sheltered corner should be made of a smaller box which is placed inside the cage. All animals need to have a place in which to hide.

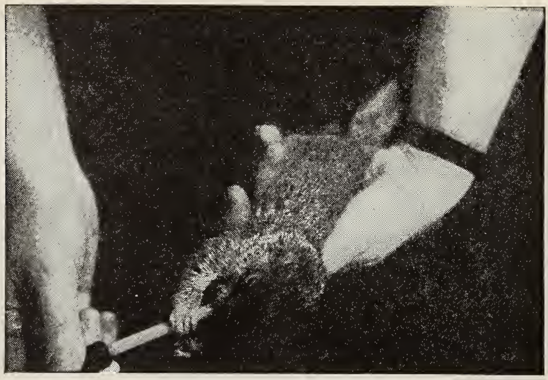
Sawdust or straw should cover the floor of the cage and be replaced with fresh material every day. If a layer of newspaper is put on the floor first, the cage can be more easily cleaned. The animal will carry some of the material into its sheltered corner.

Guinea pigs and white rats are more easily kept in a schoolroom than rabbits. Rabbits may be brought in for a day or two, but it is better for them to live out of doors.

These rodents may be fed oats, alfalfa hay, carrots, and other vegetables. The young ones should have milk and a few drops of cod liver oil each day during the time when they do not get plenty of sunshine. Evaporated milk diluted with warm water is more easily digested by these small mammals than is fresh milk.

If the schoolroom is closed and becomes either very hot or cold over the week-ends, the animals should be taken to the home of one of the children. Extremes of temperature are not good for warm-blooded animals, particularly when in captivity where they can't protect themselves.

Although many of these animals are able to get their water from



Feeding a young squirrel.

their food, water should always be provided in the cages. The container should be low enough for the animal to drink from and of a kind not easily tipped over.

Wild rodents, such as meadow mice, squirrels, and chipmunks are sometimes brought into the schoolroom. Adult wild animals are difficult to tame and often refuse to eat. Young wild rodents, however, may be cared for and make interesting pets. If they are very young they may be fed on warm, diluted evaporated milk. The smaller the animal the more warm water should be added to the milk, the more frequently it should be fed, and the less it should have at each feeding. One needs to use common sense in caring for these young animals. Keep them warm, let them alone as much as possible, and don't overfeed them.

Children sometimes bring other young mammals to school. Until the animal is old enough to eat solid food, its care is the same as for the other animals mentioned above. Teachers may find detailed directions for rearing all kinds of wild animals in Moore's *Wild Pets*. See reference list.

Young birds are easily reared if you know the food to give them. Any good bird book will tell the food of the common species of birds. Insect-eating birds may be fed earthworms, caterpillars, and small larvae of beetles. Hard-boiled eggs may be substituted

for part of their food. The shells should be crushed and fed with the egg. Young flickers may be fed raw eggs and ants.

Seed-eating birds may be fed any kind of small seeds. Chick-feed is easily obtained. Some bread may be given them but should be supplemented with seeds. All birds need sand and other hard foods.

When a bird is first found it may have to be fed forcibly. Open its beak gently and put the food in the back of its throat. A pair of forceps or tweezers is useful in accomplishing this. The bird won't swallow unless the food touches the swallowing center on the back of its tongue.

Fish-eating birds such as bitterns and loons are occasionally found and brought to school. These are problems to feed as they do not thrive on dead fish. The author has successfully fed young fish-eating birds on live tadpoles and minnows.

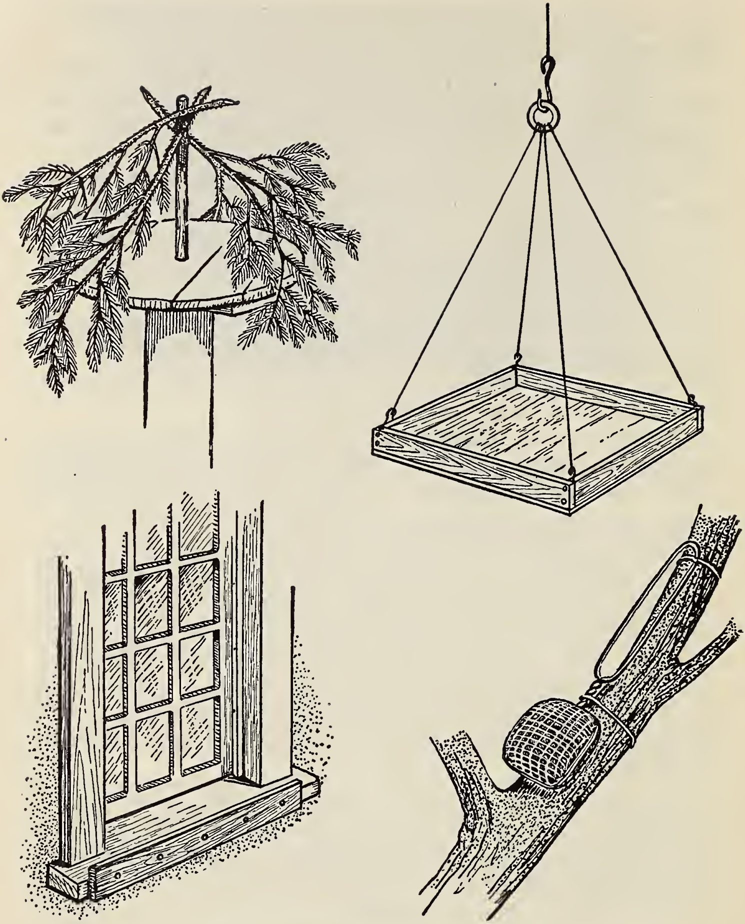
Hawks and owls may be fed pieces of meat which have been wrapped in cotton or rolled in sand. These birds should be handled with care as their bite is painful. Young ones soon learn where their food is coming from and open their mouths.

Unless a wild animal is too young to care for itself, it is wise to keep it awhile for study and then release it. School buildings are not built to house the lower animals. A trip to a well-run zoo will demonstrate how varied are the needs of the different groups of animals. It would be impossible to duplicate these conditions in a room where children live. A cage built outside a window on a level with the window sill will partially solve the problem. If a squirrel or rabbit is to be kept for any length of time this might be worth while.

In caring for any animal, the children should be made to feel responsible. They should read about the natural habitat and food of the animal and try as nearly as possible to duplicate these conditions. Even though some animals die, the value to the children makes caring for them worth while.

WINTER BIRD FEEDING

In the northern part of the United States most of the common birds migrate in the autumn but there are a few that remain through the winter. Why birds migrate is a question no one has



Simple feeding stations for birds.

solved satisfactorily, although there has been much written on the subject. The teacher should familiarize herself with the theories of migration and not try to solve the problem.

Half a coconut may be filled with melted fat.

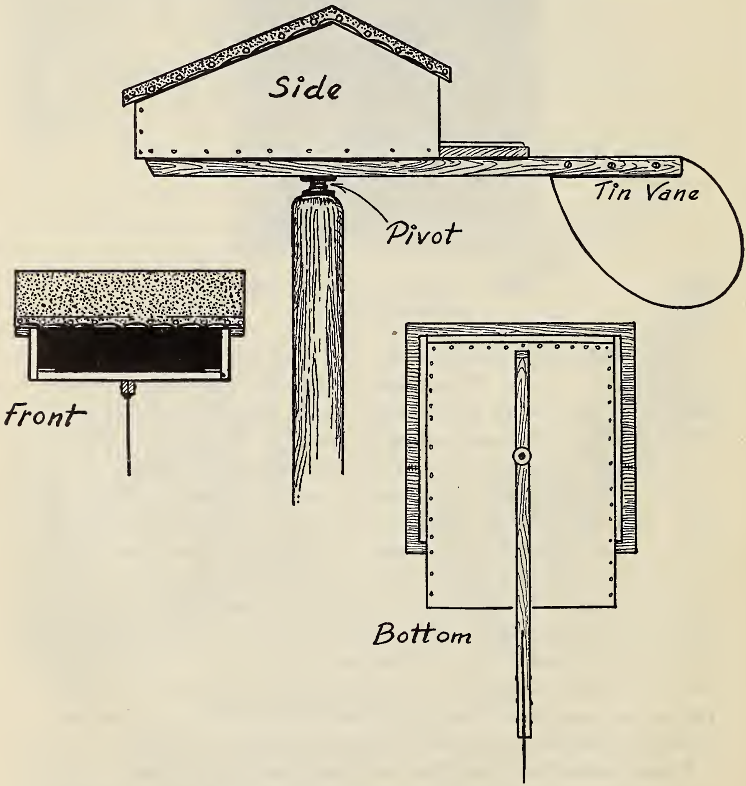
Some winter bird residents stay the year around in the north. Among these are the chickadees, nuthatches, and downy woodpeckers. Others come from farther north, spend the winter, and return to their northern nesting grounds in the spring. Brown creepers, juncoes, and tree sparrows are examples of these.

Some winter birds are insect-eaters and some feed on seeds or fruit. The downy woodpecker is able to chisel through the bark of a tree and with its tongue spear the larvae underneath. Nuthatches and brown creepers get insect eggs and insects from the crevices in the bark. Chickadees and titmice find their insect food mostly in the buds and on the twigs of shrubs or trees. But in winter, all of these will eat whatever they can find. Since they are meat-eaters, we put suet or nuts on the feeding shelf for them. To prevent suet from being carried away by a blue jay or starling, it may be put into a wire basket made of coarse screening.

A soap shaker may be filled with suet and hung from a wire. The suet may be tacked to a tree or tied to a limb. The nuts

should be crushed or finely cracked to prevent squirrels from carrying them away. Birds will scratch among the shells and pick up the bits of nut meats. Walnuts or hickory nuts are good bird food, and may be gathered by the children in the autumn, to save for winter feeding. Half a coconut may be filled with melted fat and hung from a branch. Cracked nuts or seeds may be added to the fat.

Juncoes, sparrows, goldfinches, and cardinals are seed-eaters.



A more elaborate feeding station.

Any seeds, such as wheat, oats, millet, or cracked corn, will attract them. Sweepings from a mill are welcomed by birds and they will scratch in the chaff for days, finding tidbits. Cardinals and grosbeaks are especially fond of sunflower seeds. Crumbs of any kind will attract birds, as will berries and pieces of other fruits. The children can put out discarded apple cores and cranberries. Breakfast food or other cereals which might be discarded because of weevils are good bird food. Even weed seeds are attractive to birds. Dried fruit will attract some birds.

Shrubs with berries on them always attract birds. Among these are snowberry, barberry, high-bush cranberry, wild plum or cherry, and bush honeysuckle. Teachers who have anything to do with landscaping the school grounds should see that some such shrubs are planted.

A simple shelf is as effective as a more elaborate one. Just an extension from the window will work, although a roof prevents snow from covering the food. The birds may not come at first, so a good way to get them started is to sprinkle some grain on the ground under the shelf. The sparrows will come first and though we do not care so much for them, they show the other birds the way. A dry doughnut dangling at the end of a string will provide entertainment equal to circus acrobats. Peanuts fastened to a string stretched across the window or between trees will also attract birds.

A swinging shelf usually frightens sparrows and drives them away. However, for teaching purposes in the primary grades even an English sparrow has possibilities.

In snowy, freezing weather, water is as hard for birds to get as is food, so water should be put out for them each day. It will often attract birds not attracted by food. A shallow earthenware container like the saucer of a flower pot is good for this purpose.

FIELD TRIPS

If properly conducted, a field trip may be an important activity to help in the solving of some science problem. Improperly conducted, it may be a waste of time.

A field trip must have purpose. It must come as a result of a need to learn something outside the schoolroom. It need not mean

A field trip—looking for birds' nests.

a long trip. For example, in a discussion of soil formation the question may arise of whether freezing and thawing break up rock and form soil. To illustrate this, the children may go outdoors and find rocks that have been cracked in this way. Even sidewalks and the foundations of buildings illustrate the point.

The teacher should anticipate any trip she plans and make the trip herself before she takes the children. If she intends taking the children to see birds, she should make sure that there will be birds to see. Birds are elusive and cannot be tagged and made to stay in one place. But a nest that is being built, or the work of a woodpecker located by the teacher or some member of the class, will remain until the whole class sees it. The chances of also seeing the bird will be good. With a definite objective in mind, the teacher is sure to prevent disappointment and aimless looking.

Before starting on a trip, the teacher must be sure that every

A field trip—locating territories of birds.

child knows what he is going to look for. There is endless variety in the number of interesting things to see out of doors, but unless the attention is directed to a few, there will be confusion, and no learning will result.

For example, on the way to a river to see erosion, the group may watch for terraces that have been made as the river cut down to its present bed.

A large group should be organized into small units with a leader for each. These may be working on the same problem or different problems. If unusual things are found, the whole group may be called together to see them.

A simple way to organize groups is to make enough slips of paper for each member of the class. Number them from one to five. Circle one of the number ones, one of the twos, one three,

After a field trip—rock study.

one four, and one five. Have the children draw slips. All the ones make a group. All the twos make a group, and so on. The children with the circled numbers are the leaders for the day.

Children like to make their own rules for field trips and take pride in following them. Here is a set of rules made by a third-grade class before going on a trip to study birds.

1. Walk quietly. No loud talking.
2. Follow your leader.
3. When you see a bird, stop. When the leader stops, everyone stops.
4. When you see a bird and want to show it to the rest of the group, tell them, without pointing, where it is. (Birds see better than they hear and are startled by quick motions.)
5. When you are looking at a bird, stand with your back to the sun.

Too many rules are confusing just as too many directions are. It is better to take short trips at first, trying out one rule; then add more rules as longer trips are taken. If the children understand what the trips are for, they will gain the proper attitudes toward them.

It is very important in any science work to respect the discoveries and ideas of children. When they see or find things on a trip, the group should give as serious attention to them as to the teacher's contributions. This encourages children to observe and it intensifies their interest.

On a collecting trip, enough containers should be taken along to carry back any specimens. Directions on how to collect and what to collect should be clearly understood before leaving the school. Collecting should be done only when material collected is to be used. If such material may be studied to better advantage in the schoolroom than out of doors, it serves a purpose. But only as much as is needed should be taken. Gathering hundreds of frogs' eggs would be wasteful when a few would be all the children could care for. It is better to raise a few tadpoles to adulthood than to have dozens die for lack of room or food.

Some of the types of trips may be listed as follows:

1. A trip to locate territories of birds. Return at regular intervals to watch nest building and rearing of young.
2. A trip to collect rocks.
3. A trip to see types of erosion.
4. A trip to find tracks of animals.
5. A trip to find and collect galls.
6. A trip to a zoo or museum to see something that has been discussed in class, such as fossils.
7. A trip to a meadow to collect weed seeds.
8. A trip to observe the sky.

The suggestions for teachers that are given later in this manual list other ways to give purpose and variety to field trips. Trips should never grow so common or become so regular as to be monotonous, nor so dull as to be meaningless. Children should always regard them with enthusiasm, not because they offer an opportunity for play, but because they are the most satisfying solution to many of their science problems.

THE HOW AND WHY SCIENCE BOOKS

BASIS FOR CHOICE OF MATERIAL

CHILDREN'S INTERESTS

Children's interests were closely studied in preparing and organizing the material used in The How and Why Science Books. The subject matter was used by the authors in actual teaching experiences over a period of several years and with many different age groups of children. The problems were used in mimeographed form until arranged for publication.

RECENT COURSES OF STUDY

The material for the books was originally chosen from units that appeared in many courses of study from many sections of the United States. City and state courses of study were consulted, as well as those prepared and used in teacher-training institutions. More recent studies, problems which have arisen in the classes of the authors, and new courses of study have added new material to the original series.

The outlines for science in the elementary grades found in the *Thirty-First Yearbook* and in the *Forty-Sixth Yearbook* of the National Society for the Study of Education have been closely followed. Some quotations from the *Forty-Sixth Yearbook* are of interest here:

"Instruction in science should begin as early as children enter school; activities involving science should be provided even in the pre-school and the kindergarten. Through the sixth grade the work in elementary science should consist of a continuous integrated program of the sort advocated by the *Thirty-First Yearbook.* Such a program should provide an expanding, spiral development of understandings, attitudes, and skills, as prescribed in chapter iii."—pp. 41–42

"It is most important that the material selected for each grade of the primary school be balanced to include the elements of learning which represent a rich experience with science. Each level should give the child some opportunity for exploration with content derived from the great major fields of science: astronomy, biology, geology, and physics. This cannot be accomplished by studying only plants and animals.

"There should also be balanced instruction as to the types of activities employed. Children should have a rich opportunity to develop their abilities in discussion, in experimentation, in observing in the out of doors, and in reading for information and motivation. A complete program of instruction in primary science can be maintained only by the full utilization of all these activities, for each plays its part in the development of the purposes of science education."—p. 84

"Since experimentation involves 'learning by doing,' there can be no substitute for it. Pupil experimentation is an essential part of science education. In every course of science offered at any level, therefore, opportunities should be provided for pupils to perform experiments." —p. 53

"The basic purpose of the elementary school is the development of desirable social behavior. Science, with its dynamic aspects, its insistence upon critical-mindedness and better understanding of the world, and its demand for intelligent planning, has a large contribution to make to the content and method of elementary education.

"To accomplish this basic purpose a continuous program of science instruction should be developed throughout public school education, based upon a recognition of the large ideas and basic principles of science and the elements of the scientific method. Children must be given opportunity to gain the knowledge necessary for intelligent and

cooperative experience with the world of matter, energy, and living things and to develop constructive appreciations, attitudes, and interests. This demands that the individuals in our society become intelligent with reference to the place of science in individual and social life.

"When the content and method of science are examined, it is found that the child's normal activities have much in common with the purposes of science in modern society and that the teacher can view the teaching of science as utilizing the natural dynamic drives and potentialities of children."—p. 73

"Work in the primary grades should not be exhaustive. Rather the child should feel that there is more to learn about everything that he does. A developmental point of view demands that a well-balanced program provide contacts with realities. It cannot allow omissions in the development of the concepts, principles, attitudes, appreciations, and interests derived from the field of science."—p. 82

"The new program of science, which emphasizes the development of desirable social behavior, is organized around problems that have social value and are challenging and worth while to children. The teacher must, therefore, look back of the objects of the universe to the problems which involve meanings that the children will need to understand in order to participate intelligently in life. This means that, in science, opportunities must be provided for the development of understandings in all the areas of the environment and at all levels of social needs."—p. 92

HEALTH, SAFETY, CONSERVATION, AND AERONAUTICS AS INTEGRAL PARTS OF A SCIENCE PROGRAM

The authors of The How and Why Science Series have made health, safety, conservation, and aeronautics integral parts of the science program. This is in accordance with the recommendations of the *Forty-Sixth Yearbook*:

"*What is the place in the science curriculum of conservation, aeronautics, physiology, and health education?* The materials of these areas are of value chiefly for general education. Except, perhaps, for an eighth-grade one-semester course in health and physiology, it is probably not desirable to offer separate courses in any of these subjects. Their materials can be more effectively integrated with those of the regular courses of the science sequence and with other courses in the program of studies."—p. 46

"The content of the science program in many elementary schools is now being organized around problems which have social value and which are significant in the lives of children. These problems arise from children's

interest in the world around them and from their need to meet intelligently their problems of living in areas such as health, conservation, and safety. They are solved not through the mere accumulation of facts but in such a way as to help children (1) develop meanings which are essential to social understanding, and (2) put into practice desirable social behavior. Problems involve meanings in their solution, and meanings are learned through experiences."—pp. 69–70

"A program in science should develop a large background for the teaching of health. Many schools are now integrating health entirely with science and the social studies. Science provides much of the background for the teaching of health facts and the development of health habits. Moreover, in their study of science, pupils should gain a vision of the potentialities of science in the improvement of the health of the nation and the world."—p. 76

"Likewise, science is involved in accident prevention and safety instruction. We cannot fully anticipate the environment of the future. New inventions may eliminate present hazards and create new ones, making it impossible to develop a code of conduct in safety instruction which will be functional for an entire life span. It may be well, then, in safety instruction to place more emphasis upon the scientific principles which are basic to safe conduct."—p. 77

"The place of science in bringing about the wise utilization of natural resources to the welfare of mankind is an important aspect of the science areas related to the social needs."—p. 77

HEALTH

The study of health in our public schools should be an integral part of the science program. To study health without its scientific basis is to leave the study without form or background. This fact can be illustrated by examining almost any phase of the teaching of health. Let's start, for example, with respiration.

We teach that man breathes air. In his lungs the oxygen from this air passes through the walls of the capillaries into the blood. Here because of hemoglobin in the red corpuscles, oxygen is taken with the blood to the heart and then to all parts of the body. The oxygen enters the cells. There it is united with food material that comes through the digestive tract and the blood. The food is oxidized, producing heat and other forms of energy. This is a simple little statement that one might find in a health book. Where does the oxygen come from? What is it like? What are its properties? These are science problems.

Botany teaches us that plants use carbon dioxide in making food and give off oxygen. All green plants do this. This is where part of our supply of oxygen comes from. Chemistry teaches us the properties of oxygen. It also teaches us about oxidation. It is important to know that the uniting of oxygen with other materials forms new chemical combinations. This makes it possible for the student to understand what happens in the human cell when oxidation takes place. He discovers that heat and other forms of energy are produced. In order to understand heat and its relations to other forms of energy one must understand physics. This involves the physical properties of heat, energy, and the passage of energy from one form to another.

Oxidation in the cells produces energy and gives off carbon dioxide. Carbon dioxide dissolves in the blood, is returned to the lungs, and breathed out. The student who reads the story of respiration in a health book given to health must consult botany, chemistry, and physics in order to understand the story intelligently, or the health book must contain much science material.

The student who has studied respiration as taught in the How and Why Books knows the scientific background of every step of the process; hence, he can understand the interrelationship between plants and animals. In fact, respiration becomes an intelligible story. Respiration cannot possibly be taught as an isolated phenomenon. It must be incorporated into a book covering all phases of science to be intelligible.

How does the body grow? It grows through cell reproduction. A student who understands this must understand the meaning of the word *cell.* In science this concept is developed in connection with one-celled animals and plants. The student who knows how a cell divides to form two, and the two further divide to form more cells, and how each cell is composed of a cell wall, protoplasm, and nucleus is ready to understand how the epithelial cells of the skin and mucous membranes divide and grow to cover the body. It would be impossible to teach the concept of human cells without giving a scientific background.

Another example is that of the study of digestion. Digestion begins with food. To understand digestion one must know about the various types of food. One must understand the character-

istics of each kind of food. One must know the unique function that each kind of food has in the body. In science children study these foods. They study the relation of animals to food. They study the relation of energy to food. When they have questions concerning their own digestions, they have an intelligent background of understanding. Let's take an example. A child puts some potato into his mouth. If he has studied the science of plants, he knows that a potato is a tuber. He knows that it is made up of about ninety-five per cent water and some starch. He knows, therefore, that when he starts to chew the mouthful of potato, he mixes it with saliva. He knows that there is a material in saliva which changes starch into sugar. This is a chemical change. The potato passes through the esophagus into the tomach. Here it is further mixed with other digestive juices, and the starch is completely digested into a soluble sugar. This sugar in solution passes through the walls of the intestines by the process of osmosis. What is osmosis? Osmosis is something one learns about in physics. It has to do with the pressure of different fluids and their passage through a membrane. The food travels in the blood to the cells of the body where it goes through the chemical process of oxidation. How would one teach food and digestion if he had to teach it without science? There is nothing in the program of health that can be taught as an isolated fact and be intelligible.

Let's look as muscles. Of course we must teach about muscles. We must know about cells to understand how muscles are made. How do muscles act? In the first place they get their energy by the oxidation of food in the cells. This process cannot be understood unless one understands chemistry. By using the energy produced by oxidation the muscles contract. When the muscles contract, they move the bones. To understand how they move the bones it is necessary to know some physics, because the muscles that move the main structure of the skeleton work on the law of levers as developed in physics. Muscular activity involves the laws of both chemistry and physics.

If we turn to the senses, it would be impossible to even attempt an explanation of how we see without some conception of the physics of light. It would be impossible to understand the use of glasses unless one knows the laws of refraction that are taught in

physics. It would be impossible to know how the eye functions to focus the light on the retina and understand what happens to light waves as they pass through certain types of media. We must have some knowledge of the physics of sound and how the vibrations work to understand how the process of hearing takes place.

Health principles are based on scientific fact. The How and Why Science Books have put the health program in the science field where it belongs. The development of science concepts throughout the books advances the basic health rules logically and naturally.

SAFETY

Safety is taught both in connection with health and as a part of scientific procedure. In the intermediate books of The How and Why Science Series the following concepts contribute to an understanding of principles of safety.

The How and Why Club:

pp.	5	Care in riding bicycles on the highway.
	6–9	Safety regulations at an airport.
	40	Safety in using chemicals.
	80	Recognition of the only poisonous spider in the United States.
	159–174	How to keep food from spoiling.
	176–179	Pasteurization.
	197	How to tell directions at night.
	237–243	Safety in using tools.
	245–247	Protection of the eyes from the sun.
	315	Avoiding danger from lightning.
	324	Use of fuses to prevent fires.

How and Why Experiments:

pp.	26–29	Harmful fungi and bacteria and how to eradicate them.
	89–91	Man's protection against weather.
	112–115	Protection against insects that carry disease.
	116–121	Immunization against diseases.
	167, 168,	170 and wherever fire is used in an experiment. Safety rules for using fire.

209	How to make and use a fire extinguisher.
210	How to avoid carbon monoxide poisoning.

How and Why Discoveries:

pp. 42	Use of alcohol on a needle to kill bacteria.
251–252	How a rescue bell works.
289–293	How water can be purified.
305	Use of electrical switches.
313–315	Protection from electricity.
355–374	Prevention of disease.

CONSERVATION

Many activities in science may contribute to the objectives of conservation education.

Dr. Ira N. Gabrielson, director of the Fish and Wildlife Service of the U. S. Dept. of Interior, in his book *Wildlife Conservation* says, "the various programs for the conservation of soil, water, forests and wildlife are so closely interwoven that each vitally affects one or more of the others. All are phases of a single problem —that concerned with the restoration and future wise use of our renewable natural resources. . . . The term 'conservation,' when applied to the two classes of renewable and nonrenewable resources, carries quite different meanings. The conservation of the inorganic or nonrenewable resources, such as coal, iron, copper and oil, means sparing use with no waste. The conservation of organic resources implies use, but only to an extent that will permit a continual renewal."

The scientist's concept of conservation has changed in the last few years and broadened to include not only minerals and wild life but human resources as well. It is with this last resource that elementary teachers are most concerned. To conserve human life and well being for future generations, it is particularly important that we take thought today. The children we are teaching are facing a very uncertain world, politically and economically. Someone has said "Our children are living in the world of today, we are not." We need to take stock of our curricula and see whether or not this is true. Are we teaching the things that are vital to the preservation of the race or are we still clinging to the patterns we ourselves were taught to follow? If conservation is vital to the

preservation of man, how can we make it a vital part of our science program?

In the first place we must find natural ways in which the problems of conservation fit into the lives of the particular groups we teach. Suggestions have been given in various places in the intermediate books of the How and Why Science Series for discussing conservation of plants, animals, soil, and water. The ways that arise will depend upon the conservation needs of the region. In one region it might be soil, another game, another water, another forests. In a crowded city district it might be utterly out of place to discuss wild-life conservation with children who lack food and sunshine. Ways and means of helping these children to build strong bodies would obviously be the conservation program needed there.

Teachers need to be careful not to become so enthusiastic about the subject of conservation as to forget that they are teaching children, not subjects. As adults we should be much concerned about the future and its resources. Children cannot and probably should not be confronted with such remote problems. If the best trained men in the country have been able to do little about soil erosion and flood control, certainly children can't attack the problems.

But children can see what rain and melting snows do to their lawns and terraces. They can see the results of malnutrition in other children. Pictures of the children in starving countries continually bring this to mind. They can attack problems of plant and animal interdependence as suggested in various units in the How and Why Science Books. The attitudes, habits, and appreciations gained in these units may be easily made a part of a conservation program.

Concepts contributing to an understanding of conservation are taught in the following chapters of the intermediate books:

The How and Why Club:

pp.	44–59	How Beavers Live
	73–83	A Spider's Bridge
	84–87	More About Spiders
	89–93	Plants Depend on Animals

How and Why Experiments:

How and Why Discoveries:

AERONAUTICS

Although World War II gave an added importance to the subject of aeronautics, and a considerable number of separate courses in this field are being taught, chiefly in the senior high school, the authors of The How and Why Science Series believe that this subject can be more effectively integrated with the regular science course. Beginning in the Pre-Primer, the books of the series provide valuable and adequate instruction about the science of flight. Again, this material takes its place as a part of the science program in the study of air and its properties.

In the intermediate books, the following concepts contribute to an understanding of aeronautics.

The How and Why Club:

pp. 6–16 Airplanes land on special landing fields.
Airplanes have many safety regulations and devices.

Pilots must obey signals and regulations for their own and their passengers' safety.

Passengers, visitors, and the ground crew must also obey safety regulations.

Weather is one of the most important factors in flying.

A pilot must know the direction and force of wind before landing. He must also know which runway to use.

Red and green lights are used to signal when a plane is to land.

The important parts of an airplane are: propeller, engine, landing gear, fuselage, wings, ailerons, elevator, rudder, nose, and stick.

197 The stars have helped guide aviators to safety.

How and Why Experiments:

pp. 175–177 Four main forces that act upon an airplane are gravity, lift, thrust, and drag.

The force of gravity is overcome by lift.

The wings of an airplane are built so that the pressure on the top of the wing is less than the pressure on the underside. This produces lift.

The force that moves the plane along the ground is thrust.

Drag, the force trying to hold the plane back, is caused by the resistance of the air to the forward movement of the plane.

How and Why Discoveries:

pp. 169 Weather presents many hazards to the aviator.

187 To determine the speed and direction of the wind, weather observers send up a radiosonde consisting of a balloon which carries instruments to measure temperature, pressure, and humidity.

188–189 Air travel is made possible by constant use of weather predictions.

All air travel is controlled by the Civil Aeronau-

tics Administration. No clearance will be given any plane unless the weather report is favorable.

270–279 A balloon will rise when the air inside the balloon is much lighter than the air in the atmosphere surrounding the balloon.

A dirigible is equiped with an engine that drives it forward, and a steering device.

A helicopter is a powered plane with rotating wings connected with the engine.

An autogiro is similar to a helicopter. The engine is connected with a propeller and the rotor is set in motion by the action of the air and the movement of the plane.

A glider is a heavier-than-air craft having no power, no engine, and no propeller. When launched, it is carried by wind currents and updrafts of air.

A parachute is used to check the fall of a jumper.

THE PLAN OF THE INTERMEDIATE SERIES

THE ORGANIZATION OF MATERIAL

The intermediate books of the HOW AND WHY SCIENCE SERIES enlarge upon the concepts presented in the primary books and introduce new ones. An effort has been made to show how the simpler concepts contribute to more complex concepts and principles. The material is organized around major problems which might easily grow out of children's questions if properly introduced.

THE SCIENCE CLUB

The idea of a science club as introduced in THE HOW AND WHY CLUB may be used to advantage throughout the intermediate grades. A science meeting at the beginning of each class period gives the children an opportunity to relate the experiences they have had outside the classroom. It gives them training in conducting a meeting of their own, and thus contributes to their social development. It helps develop their curiosity concerning their

environment and ability to observe accurately. It gives them an opportunity to ask questions and thus gives the teacher an excellent key to their natural interests.

ILLUSTRATIVE MATERIAL

Environment and individual differences play such an important part in children's science interests that the teacher must be guided by her own group in the choice of problems. Some problems may have to be teacher-motivated because lack of experience on the part of her group may mean that the children will not initiate them. Once introduced to the material, children should accept it with interest, otherwise it is not suitable for them.

The teacher who has had little science experience will find help in knowing what may interest her group from the suggestions given in this and other Manuals for the series, but *she should always be ready to follow child-initiated activities when they arise.* She should not be like the teacher who, having planned a lesson on buds, was disturbed when Johnny brought in a turtle. "Take it right back," she said. "Today we are studying buds."

Illustrative material should come primarily from the child's own environment, but not exclusively so. In this regard the *Thirty-First Yearbook,* page 148, states:

> "Some have contended that no illustrative material should be used except that which is in the natural environment of the school. This seems to be a very narrow interpretation of illustrative material. In this day when the child listens to the events happening in Antarctica, or other far parts of the earth, in which his environment is spreading out so that the whole world comes into his own home in one way or another, to restrict the illustrative material to local, indigenous objects seems, indeed, to be inexcusable."

The subject matter of THE HOW AND WHY SCIENCE SERIES has been arranged to appeal to as many different groups as possible. Biological units have been chosen in such a way that different sections of the United States are represented. Illustrative material is taken from the East, the West, the Middle States, and the South, thus broadening the scientific concepts acquired by the children using these books.

There is a Companion Book to accompany each of the texts. If used as designed, these Companion Books should help attain the following objectives:

1. The extension and enrichment of science concepts and interests.
2. The development of scientific attitudes.
3. The further development and understanding of the scientific method of problem solving.
4. The clarifying and fixing of correct science concepts.
5. The promotion of language growth.

In the intermediate grades, these objectives may be achieved in many ways. Some of the methods used in the Companion Books are applying concepts to new situations, solving problems, recording data gathered through experimentation or field trips, making charts and maps, working puzzles, and taking objective tests of various types.

The authors are convinced that as the children acquire more skills, new learning should take place—that the Companion Books should not be just testing programs but an application of principles and concepts to new situations; that the lessons should require the using of skills which are necessary in gathering scientific data and solving problems to attack problems similar to those the children have read about in the text. In addition, the books provide interesting, individual activities for summarizing, testing, and recording group work in science.

AN OUTLINE SHOWING THE DEVELOPMENT OF CONCEPTS

Although each Teacher's Manual contains a detailed outline for a year's work, the plan and organization of the three intermediate books of The How and Why Science Series are shown in chart form on the next two pages.

A large, more detailed chart is published separately. In this separate chart the horizontal development shows in more detail the growth of the concepts, and the vertical columns present more elaborate outlines of the material covered in each book.

Content Areas	*The How and Why Club—Book IV*
LIVING THINGS ANIMALS (*See also detailed chart published separately*)	Animals have structural characteristics and habits which have made it possible for them to survive. Many animals are very important to man.
PLANTS (*See also detailed chart published separately*)	Plants have characteristics and life processes which have made it possible for them to survive. Plants are very important to man.
THE BALANCE OF NATURE (*See also detailed chart published separately*)	Plants and animals depend upon each other.
PHYSICAL ENVIRONMENT WEATHER (*See also detailed chart published separately*)	The weather affects the surface of the earth.
THE SOLAR SYSTEM (*See also detailed chart published separately*)	The sun and moon affect the earth. Some constellations we see in the winter sky.
EARTH STUDY (*See also detailed chart published separately*)	The surface of the earth is continually changing. Fossils.
FORMS OF ENERGY (*See also detailed chart published separately*)	Heat is important to us. Light is important to us. Magnetism helps us. Electricity is important to us.
AVIATION (*See also detailed chart published separately*)	Aviators must follow regulations. A plane is built to fly.
HEALTH STRUCTURE AND CARE OF THE BODY (*See also detailed chart published separately*)	The teeth are important parts of the body. Bones and muscles are important. Our bodies need fresh air.
FOOD AND DIGESTION (*See also detailed chart published separately*)	The body needs food for growth and energy. Foods have to be digested before the body can use them.
BACTERIA AND DISEASE (*See also detailed chart published separately*)	Foods should be kept from spoiling.

How and Why Experiments—Book V	*How and Why Discoveries—Book VI*
Animals have modifications and life processes which have made it possible for them to survive.	Animals are continually struggling for existence. The most important factor in the struggle is food. Animals are able to get food by means of special structures that fit them to the particular food they eat. Animals use food for growth and energy. Species of animals have survived because of these modifications and life processes. Water birds are especially fitted for life in or near the water. Other water animals are adapted for life in or near the water.
Plants have modifications and life processes which have made it possible for them to survive.	Plants grow and reproduce by means of cells. Water plants have characteristics which enable them to live near or in the water.
Man has upset the balance of nature by destroying wild life.	Man is now trying to repair the damage he has done to the balance of nature by conserving wild life. There is an interdependence between the plants and animals in a pond.
The factors involved in weather are air, sun, and water.	The Weather Bureau helps us by forecasting the weather.
The movements of the earth affect our lives.	The earth is a part of the universe. The earth belongs to the solar system. The earth and the moon. Besides planets and stars, there are other heavenly bodies. Astronomers use many instruments in studying the sky.
	The story of the earth. The importance of minerals to man.
Heat is produced in several ways. Air is used by man to do work. Electricity causes lightning. Machines make work easier. Sound is important to us.	Man uses air in many ways. Water is important to man. Magnetism and electricity. Sound is an important form of energy.
Planes use air pressure to fly.	Man travels through the air in several ways.
The skeleton does important work. The muscles do important work. The nerves do important work. The body needs care if it is to work well.	The skin is made up of cells. The body needs care if it is to build up resistance to disease.
Foods keep our bodies warm. Foods have to be digested and circulated so they can produce energy.	Human beings eat for energy. The relation of water to health.
Bacteria are plants that are important to man.	The community health should be safeguarded. Diseases have causes.

HOW AND WHY DISCOVERIES—BOOK VI

SCIENCE PROBLEMS

I. ANIMALS NEED FOOD FOR ENERGY AND GROWTH

Problem A. How do animals get food?

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3. How do birds get food?
4. How do reptiles get their food?
5. How do amphibians get their food?
6. How do fish get their food?
7. How do insects, spiders, snails, clams, and earthworms get their food?

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XII. COMMUNITY HEALTH

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ACTIVITIES USEFUL IN SOLVING THE PROBLEMS IN

HOW AND WHY DISCOVERIES

I. ANIMALS NEED FOOD FOR ENERGY AND GROWTH

(Pages 5–61)

Problem A. How Do Animals Get Food? (Pages 5–34)

Science Concepts:

1. Obtaining food is the main factor in the struggle for existence.
2. Each animal has modifications for getting food in its environment.
3. The higher an animal is in its development, the more efficient its method of obtaining food.
4. The present animal species have probably survived because they had better modifications for obtaining food than the species that did not survive.

This problem presupposes that the children have some knowledge of animal groups and their structural characteristics.

The purpose of the problem is to develop further the possible reasons that the present animal species have survived while others have become extinct.

If a zoo is available, children should visit it and see the animals mentioned in this chapter. Notice how similar to dogs are the seals, wolves, and raccoons, and how similar to cats are lions, tigers, leopards, and panthers. Skunks and weasels are closely related and have teeth much like a cat's.

Try to obtain skulls of members of this group so children can see the teeth and compare them with those of a pet cat or dog. Discuss how the teeth have helped the animals to survive. Notice that a dog cannot grind as we can, but that his jaw moves up and down in a crushing movement. Thus starchy foods that need to be

digested partly in the mouth are not too good for dogs, unless they are so hard as to need crushing. Some starchy foods may be given if they are hard.

Wild carnivorous animals feed entirely on other animals, but by eating the whole animal they get the minerals and vitamins often lacking in the meat we feed our pets. Since many children of this age have pet dogs or cats, this is a good time to discuss their diet. See pet books or bulletins for information.

The plant-eating mammals consist of several orders of which rodents and ungulates are most common. The rodents were discussed in detail in THE HOW AND WHY CLUB and need to be briefly reviewed here merely as they contribute to the problem. Children often have questions concerning the care and feeding of rabbits, guinea pigs, and squirrels. U. S. Department of Agriculture bulletins and state 4-H bulletins are excellent sources of information on the care of these animals. Pet prairie dogs are sometimes brought to school, and furnish good examples for study.

The harmful work done by rats and mice would be a good way to introduce this problem in a region where these animals are pests. Where rabbits or other rodents are pests, they should be studied also. The question "Why are these animals harmful?" should start a discussion of their feeding habits.

In rural areas, children often raise cattle, sheep, horses, and pigs as a part of their 4-H Club work. Many boys and girls help earn money in this way. A teacher may make use of this interest to bring out scientific principles. Here man uses the laws of heredity and variation to improve domestic animals. He uses scientific knowledge of the feeding habits of these animals to further improve the stock. A visit to a county or state fair is a good learning activity. The children should note the condition of the prize animals and compare with the condition of poorly-fed and poorly-cared-for animals.

The insect-eating mammals include bats, moles, shrews, and hedgehogs. Skunks also eat insects, especially in the larval stage.

Here is a good opportunity to remove a fear of bats that many children have; also to correct the misconception that "bats get in your hair," or other superstitions concerning these night-flying creatures.

If a bat is brought to school, use the opportunity to discuss its habits. Put it into a cage and observe its habit of clinging upside down. Notice the elongated "finger" bones that form the skeleton for the wings. The delicate membrane stretching between these bones and the hind legs is very sensitive to touch.

Children often exclaim when first they see a bat closely, "Oh, it looks like a mouse!" This gives rise to a discussion of the classification of bats and settles the question, "Are bats birds?"

Sometimes a female bat is found with young clinging to her. Observation of these will further establish the correct concept that bats are mammals.

One group of children found a bat in the schoolroom, caught it and brought it to the science class. When some child said, "Look out, it will get in your hair," another child told of her experience at Carlsbad Caverns, and of the guide's assurance that bats were harmless. Another child told of a story she had read of the experiment in which bats were released in a room having wires strung across it. "The bats flew all around the room and didn't touch the wires," she said, "I don't believe they would be apt to get into your hair if their wings are that sensitive." "I saw little lines in their wings that looked like nerves," remarked another child. Many articles have appeared in recent magazines comparing the sensitivity of a bat to the use of radar. It is believed that the bat receives reflected waves from objects it approaches, much as aviators receive reflected radio waves.

When an object moves near a bat in a cage, the bat opens its mouth and clicks its teeth. These teeth, though tiny, are sharp, and can inflict a small wound, if one is not careful in handling the animal. The author has been bitten several times but treated the wounds with alcohol, and they quickly healed. The way to hold a bat is by the loose skin at the nape of its neck. Then its wings may be stretched out enough to see their structure.

Since bats eat insects, mostly mosquitoes, they are very helpful animals. They are difficult to feed in captivity and should be released after they have been observed. If a bat nursling is found and brought to school, feed it on warm diluted milk, preferably condensed. At first its mouth may have to be opened by force, and drops of the liquid put into it. Later the young bat may suck

pieces of bread saturated in milk and fastened to the side of the cage. Normally a young bat nurses head down.

"How Human Beings Get Food" reviews human teeth and is an opportunity to teach some things about diet. It integrates well with a social studies unit of other countries, for, though all human beings have the same kind of teeth, their eating habits differ. An interesting exhibit or bulletin board may be made of the foods of other races or peoples, or a food map may be made.

When studying the food of birds, a comparison should be made of the mouths of birds and mammals.

Prehistoric birds probably had teeth. We think that birds were derived from flying reptilian ancestors. Fossil ancestors of birds have beaks more like an alligator's beak than that of modern birds.

Children may look at the beaks of as many live birds as are available in the region. A museum, aviary, or pet shop will give children an opportunity to observe different types of beaks more closely and to compare their shapes. After discussing the diagrams on pages 14, 15, 16, 17, 18, and 19, the children may look for birds that they think may eat these various types of food. They may make puzzles with sketches of beaks and let the other children guess the kind of food each beak could get. Be sure to bring out the principle here that the birds having these beaks do not have them *in order* to eat the particular food, but that they eat the food *because they have that type of beak.* The species has survived because it was able to get food.

The sub-problem of how reptiles get food offers another opportunity to destroy superstitions and to correct misconceptions. The different orders of reptiles get their food in different ways.

A garter snake kept in a terrarium may be fed earthworms and insects. After a while it may become tame enough to take the food from a pair of forceps. The swallowing process takes some time and the children will have ample opportunity to watch the snake pull the worm into its mouth. A larger garter snake will eat small frogs.

Poisonous snakes are best observed at a zoo or museum. In some regions the rattlesnake is so common that children sometimes bring live or dead ones to school. Of course teachers will not encourage children to bring live poisonous snakes to school. They

should discuss these snakes with the children and make sure that they understand the danger and how to avoid it. However, sixth-grade boys have been known to disregard caution and to capture rattlesnakes alive. This is especially likely to happen in regions where the snakes are so common that children have seen adults go out in large numbers to hunt them. They see adults capture the snakes and, as is often true, familiarity with an animal destroys fear. We want children to be free from unreasoning fear. This protects them from hysteria that leads to panic when confronted with danger. But we also wish to teach caution.

Thus if a poisonous snake is brought to school, it should be kept in a tight cage or glass container until all have an opportunity to see it and discuss how it strikes its prey. Then it should be killed. If it is in a glass jar, a piece of cotton saturated with chloroform may be quickly put in with a pair of long forceps. Be careful not to raise the lid of the jar far enough to allow the snake to strike. Utmost caution should be used in handling these snakes, even after they seem dead. A pair of heavy gloves is a wise precaution. If the teacher hasn't handled snakes, she had better ask someone who knows how to do it for her.

Since most snakes are harmless and do a large amount of good because of the kinds of food they eat, they should be protected. The rattlesnake is the only poisonous snake found in most parts of the United States. There are many varieties of rattlesnake, living in different types of habitats. The water moccasin (sometimes called cottonmouth), the copperhead, and the coral snake are the only other poisonous snakes in the United States. Teachers should consult state bulletins or write the United States Biological Survey to find out which ones are found in their particular regions. They may then familiarize themselves and the children with these particular snakes, and avoid them.

Turtles are easily kept in captivity and children will learn about their eating habits by feeding them. Turtles should be kept in a terrarium with a pool at one end or in an aquarium that is built up at one end so that the turtle may get out of the water. Some of the water turtles won't eat unless their food is under water. Some turtles prefer meat that is slightly spoiled. Some of them will eat prepared turtle food that may be obtained from a pet shop.

Horned toads and other lizards are easily kept in a terrarium with sand in it. They may be fed on any kind of insect, adult or larva. Horned toads seem to prefer ants but will eat "meal" worms or other beetle larvae. Meal worms are easily raised in culture of bran or other wheat or grain products. A "start" with directions for their care may be obtained from Turtox General Biological Supply House in Chicago. Since meal worms may be fed to any insect-eating animals, including birds, they are a good investment.

Lizards get their food by sticking out their tongues and snapping up insects. The children may count the number of insects eaten in a given time and estimate the value of the lizard.

In parts of the United States where alligators are found, children sometimes bring a young one to school. Alligators are difficult to feed in captivity and sometimes grow vicious, snapping at the fingers trying to feed them. In their native habitat, alligators eat a variety of food such as fish, frogs, and clams. They will thrive in captivity on this food. The author has fed them successfully on crayfish. They have sharp teeth with which they crush their prey.

The problem of how amphibians get food is largely review. Most children have watched frogs and toads. The difference in the way frogs and lizards get food is shown in the pictures on pages 22 and 23. The lizard's tongue is fastened in the back of its mouth, while the frog's is fastened in the front of its mouth and flops over as it is extended.

Amphibians in captivity may be fed earthworms or insects. If live food isn't available, they may be induced to eat small pieces of meat if they are put on the end of a wire and kept moving in front of the animal. Be sure to give amphibians both soil and water. They need to keep their skins moist, yet they are air-breathing in the adult stage.

The metamorphosis of the frog or toad offers an interesting study in changing food habits. The tadpole is a vegetarian with a long, much-coiled intestine. This is typical of all plant-eating animals because of the large amount of roughage a plant diet produces. The adult frog or toad is entirely carnivorous, and has a short intestine, typical of meat-eating animals.

How fish get food is easily observed in an aquarium. Some fish are surface feeders and have their mouths on the upper sides of

their heads. The bottom feeders have their mouths on the lower sides of their heads. If there is a local zoo, aquarium, or even a shop where goldfish or tropical fish are sold, the class may visit it and observe different types of fish as they are feeding.

A fish skull is easily obtained and may be examined and compared with the other skulls the children have studied. The teeth of fish are interesting as to the way they are set in the jaws. Some fish have many rows of teeth.

How insects get food should be observed and compared with food-getting by vertebrates. Since the harm done by insects is controlled only by a knowledge of their eating habits, this is an economic problem. The biting and chewing insects may be destroyed by spraying their food with poison. The sucking insects must be destroyed with a contact spray that closes their breathing pores (spiracles) and smothers the insects. Of course not all insects are harmful, but a large number of them are.

Grasshoppers can be kept in a terrarium with sprouting corn, wheat, or oats in it. Their feeding habits may be easily watched as they systematically eat the leaves. Caterpillars also cut the leaves upon which they feed with a side-to-side movement of their saw-edged mandibles. The mandibles of insects are hard structures, usually brown in color, that work much like scissors.

The long sucking tube (proboscis) of a butterfly rolls up when not in use. A Monarch butterfly, a swallowtail butterfly, or a sphinx moth may be fed with a drop of sugar solution. It will unroll the proboscis and suck from a drop of the artificial nectar.

A bee's tongue, a fly's tongue, and a mosquito's sucking tube may all be examined under a microscope and compared. This activity will help children to understand how these insects get their food and some of the ways in which they affect man.

Children are usually much interested in wasps. If a number of cells made by mud daubers are gathered and broken open, the children will discover paralyzed spiders and caterpillars. The problem of why these are in the cells is a good stimulus to a discussion of the food habits of wasps. Since wasps are common everywhere, some species may be easily observed. If a nest of the paper wasp is brought in after the first frost and put under an inverted glass container, wasps will come out as they warm up.

In the southern part of the United States, praying mantids are common. Although they belong to the same order as grasshoppers, mantids are helpful insects because of the food they eat. If some live mantids can be obtained and put into a jar with live flies, small moths, or mosquitoes, they will attack and eat the victims. In fact they will sometimes attack each other when they are placed in the same jar.

Many children will have had the experience of watching spiders catch and kill their prey. If they haven't, it is easy to obtain live spiders and to keep them in a large enough terrarium so that they can spin their webs. The spiders will capture live flies or other insects put into the container, wind silk around them, and suck the blood from the insects.

Snails have a curious method of eating. There is a rasping lingual ribbon which is a part of the tongue. The snail literally scrapes the surface from a leaf or the algae from the sides of an aquarium.

Land snails may be kept in a terrarium and fed lettuce leaves. Pond snails should always be a part of a balanced aquarium to help keep it clean. The children may watch the snails moving up and down the glass, leaving clean paths behind them. The opening and closing of their mouths may be easily observed. A big trapdoor snail such as one can buy at a ten-cent store or pet shop, will show the mouth very clearly. These trapdoor snails have another interesting life process. The young are born alive and slip out from under the edge of the shell. At first they have a flatter shell than their parent, but they are perfectly formed.

Fresh-water clams may be kept for some time in an aquarium if the aquarium doesn't get too hot. They clean up an aquarium by feeding on the microscopic organisms that flow into their bodies with the water.

The children may take a trip to a lake where clams are found. If there is a good beach, the clams will often be half buried in the shallow water near the shore. By wading near them, the children may observe the slow movements of the clams. When one is picked up, it closes quickly, shooting water from the exhalent siphon.

If one puts a clam into a jar of water with sand on the bottom,

the animal will soon open and stretch out its fleshy white "foot." Slowly it will turn until the whole anterior end (mouth end) of the body is buried and the slightly opened posterior end of the shell protrudes from the sand. In this end the siphons may be seen. If a drop of red ink is placed near the siphons with a medicine dropper, the ink may be seen going into the inhalent siphon and coming out the exhalent siphon. For food, the animal depends upon the currents set up by vibrating hair-like structures around the inhalent siphon.

Earthworms have no limbs, teeth, or other mouth-parts to help them get food. They merely extend a muscular lip that pulls into their mouths the decaying leaves and other organic material in the soil. It is this food-getting process which makes earthworms so valuable to farmers. The waste material deposited in earthworm castings contains lime and organic compound necessary for plant growth.

Earthworms may be studied by putting a few into a flowerpot of garden soil. Put about a half-inch layer of light-colored sand on top of the soil. Cover the pot with a piece of cardboard. A few small pieces of lettuce may be placed on the sand for the earthworms to eat. When the pot is uncovered after a few days, the castings of the earthworms will show on the surface of the sand.

PROBLEM B. HOW DO HUMAN BEINGS USE FOOD? (Pages 35–51)

Major Concept: Animals feed to obtain energy and breathe to release it.

Children ask many questions about their bodies. Having observed the feeding habits of other animals, the text on this problem will be easy to understand.

Before food is of any use to living things, it must be oxidized. The children should review the chapter in HOW AND WHY EXPERIMENTS on the union of carbon and oxygen to produce energy. Before the food is oxidized, it must be dissolved. This is accomplished by the processes of digestion and assimilation. Higher animals have systems of organs to digest, assimilate, and circulate food.

In the lowest animals, all the life processes take place within a

single cell. As animals become more complex, the first system they develop is the digestive system, then a simple nervous system. In worms we find the first circulatory system with blood vessels and red blood. In insects we find divisions of the body.

Man has come a long way from these lower animals. Yet in many ways his life processes are very similar. Children can watch the pulsation of the blood vessels in an earthworm. They can feel the pulsation of their own blood vessels in their wrists and their throats.

There is a misconception that the heart is on the left side. The heart is in the middle of the thorax (chest cavity), but because the left side is made of thicker muscle and pumps the blood to all parts of the body, there is a slight swinging to the left as it beats. The beat of the heart is really a contraction which begins at the apex or bottom of the heart and spreads from the lower end of the ventricles to the auricles. This contraction squeezes the blood out through the aorta and the pulmonary arteries. As the heart relaxes, blood flows into the auricles from the vena cava and pulmonary veins. The teacher should study a good diagram of the heart and blood vessels so that she may be able to help the children understand their circulatory systems.

It is probably wiser for the teacher to prick her own finger for the demonstration given on page 42 unless some child volunteers. Be sure to use a new sharp needle and sterilize it and the skin with alcohol.

The corpuscles will be so numerous in the drop of blood that it may need to be diluted before it is put under the microscope. Use a salt solution to dilute the blood, about the proportions of a teaspoonful of salt to a pint of water. Water alone will take the hemoglobin out of the blood. Put a drop of the solution on a slide, then touch the solution with the drop of blood. The blood will mix with the salt solution. The red corpuscles should appear as straw-colored disks slightly flattened in the centers. They often stack up like saucers as the blood coagulates or dries. The white corpuscles may not show, but if they do they will be irregular in shape and colorless.

A demonstration that is very exciting is to observe the circulation of blood in the foot of a frog. Wrap the frog in wet cheesecloth to

keep it moist, leaving a hind leg sticking out. With broad strips of cheesecloth tie the wrapped frog to a thin piece of wood, like a shingle. Have a hole in the shingle. Stretch the foot of the frog over the hole so that the web between the toes is stretched flat. This can be done by tying soft yarn or small strips of cloth to the toes. Mount the shingle on a microscope stage with the hole over the aperture in the stage. Focus the low power of the microscope on the web of the frog's foot. You can see the small blood vessels and capillaries with the corpuscles racing through them. It is worth the effort to hear the exclamations of the children. There are some good moving picture films showing this, also. The tail of a fish, or a tadpole, may be used in the same way.

If a model of the heart or a mannikin is available, sixth-grade children will be intensely interested in examining it. A real heart, chicken, turkey, pig or any other kind one can obtain, will be even better. Ask the butcher to remove the heart with the top intact and surrounded by its covering (pericardium). If it is filled with water the children can see the valves float up, closing the openings between the auricles and ventricles. Let them handle the heart, after it is thoroughly washed, and find the openings with their fingers. They may have read all about hearts in their books, but first-hand experience will clarify their concepts.

The picture on page 39 is diagrammatic. Its purpose is to fix in mind the direction of flow, but of course there are veins and arteries on both sides of the body as shown on page 40.

An interesting activity is to count the heartbeat. The teacher may watch the time, saying, "Start—Stop." Let all children find their pulses, then start counting when the command comes. They may count for fifteen seconds; stop, start, and count for fifteen more; then estimate the beats per minute. The average for children of this age when sitting may be anywhere from 70–80. A little higher or lower is not unusual, and they will not be very accurate. Some of them may jump up and down a few times and then let someone else count their pulses.

Following digestion, assimilation, and circulation, the food is oxidized. In human beings a respiratory system, consisting of trachea, bronchi, and lungs, provides the passageway by which air enters the body.

There is a common misconception that we breathe with our diaphragms. Actually, the process of breathing is something like this. The CO_2 in the blood flows over the respiratory center at the base of the brain. It stimulates the center to send a message to contract to the intercostal muscles controlling the ribs. The muscles contract and pull the ribs out and up. This lessens the pressure in the thoracic cavity between the ribs and the lungs. The atmospheric pressure outside the body is then greater than that in the thoracic cavity and the air is pushed in, equalizing the pressure. Then the intercostal muscles relax, the ribs collapse, and the air is pushed out. The children can raise their arms and feel the air rush into their noses.

This may be demonstrated with a transparent bag, such as waxed paper or cellophane. Blow just a little air into the bag and fasten the top tightly around a glass tube which has a small toy balloon fastened to its lower end. The toy balloon represents the lungs; the tube, the trachea or windpipe; and the larger bag, the thoracic cavity. When you press on the sides of the outside bag, the balloon will collapse. When you pull out the sides of the bag, the balloon fills.

The diaphragm is a wall between the thoracic and abdominal cavities. Mammals are the only animals having diaphragms. The diaphragm is shaped like an inverted mixing bowl and attached to the abdominal wall with heavy muscles. As the ribs are lifted, increasing the diameter of the thorax, the diaphragm is flattened because it is pulled outward. It is the result rather than the cause of breathing. While breathing *can* be voluntary, it seldom is.

After air goes into the lungs and fills the tiny sacs (the alveoli), what happens? Oxygen is needed by the red corpuscles that have entered the capillaries of the lungs by way of the pulmonary arteries and arterioles, so oxygen passes through the thin walls of the alveoli and into the capillaries. Carbon dioxide, which has come to the lungs dissolved in the blood plasma, goes through the alveoli walls and is breathed out. The oxygen-laden blood flows on to the heart through the pulmonary veins and is pumped out to all parts of the body. At the body cells, oxygen is released to pass into the cells and combine with food, thus releasing energy. This is internal respiration.

Here is a good place to teach artificial respiration. Some of the children may have learned how to do this and can demonstrate the procedure.

Many sixth-grade boys and girls belong to some organization like Scouts, that stresses health and safety. They are often much interested in meal planning. The list of a day's food requirements given on page 51 may be used as a guide for meal planning. The teacher may go as far as she wishes with having children check or plan meals. Some groups will need this more than others. In some schools, where children's parents are financially unable to provide proper meals, this may be a real problem. Children should not be embarrassed, but the teacher may help plan balanced meals of less expensive foods.

Problem C. How Do Animals Use Food? (Pages 52–53)

In many of the lower animals, the respiratory organs may be partially seen. The children may look for the spiracles on various insects. The breathing motion of the abdomen is easily seen on a grasshopper. Since its skeleton is external, an insect's abdomen consists of half rings of chitin fitting over each other in such a way as to be movable when the insect breathes.

The lower edges of the carapace of a crayfish are open to allow the entrance of water. Put a crayfish into a glass dish of water and look at it from beneath. You may observe the water moving under the edges of the carapace more easily if red ink is added to the water.

Children who have been fishing have seen the gills of fish as the fish were strung on a string. In the higher fish there is a gill cover which protects the gills on each side. There are five pairs of gills, but as the fish breathes one sees only the gill covers move up and down. The fish breathes by opening its mouth and taking in water. The water flows between the gills and out under the gill covers.

Although the digestive, circulatory, and respiratory systems of the lower vertebrates are simpler than man's, the processes are essentially the same. Children should observe the live animals where it is possible, and watch them eat and breathe.

Problem D. How Do Animals Grow? (Pages 54–61)

The concept of a cell is a difficult one for children to comprehend, even if they have a microscope to use. A few kinds of cells are large enough to be seen with the naked eye. A frog's egg is one of these, but most cells are microscopic.

The teacher should make an effort to obtain a microscope and show the children different kinds of cells.

Water from an aquarium or pond usually has one-celled plants and animals in it. Sometimes these may be seen dividing. A little mucus, scraped with a silver knife from the inside of the cheek, will show mucous membrane cells.

With two needles, tear apart a bit of muscle from lean meat and mount under low power. The elongated cells are easily seen.

Bone cells are difficult to prepare and mount because bone is so hard. Teachers may be able to borrow slides from the biology or health teacher who may have charts showing cells and cell division.

No attempt should be made to teach children the complicated process of mitosis. It is enough for them to know that cells divide.

One class discovered snail eggs on the sides of their aquarium. When these were examined under the microscope, the children saw that some consisted of one cell, some were two-celled, and some were clusters of cells. This was a fourth grade, but by watching the snails develop day by day, they gained a pretty good idea of the way cells grow and multiply.

The purpose here is not to try to teach the complicated mechanism by which cells divide. It is to give children some basis for understanding growth and reproduction. This part of the problem should be taught in the spring when material for illustration is plentiful.

Frog eggs may be seen dividing if you have good magnifying glasses and gather the eggs immediately after they are laid and fertilized. Division starts about a half hour after fertilization and continues at about that rate. After it reaches the berry-like stage, the cells are too small to be seen without the compound microscope.

Plant cells are easily obtained and seen through the microscope.

In the diagram of the onion skin on page 61, the cells are elongated. The rectangular objects are crystals that are often found in plant cells of some species. A drop of dilute iodine on the slide will stain the nuclei of the cells so you can see them.

The epidermal cells of the geranium leaf show the specialized guard cells around the stomata. The lower epidermis may be pulled off with a knife point. There are many kinds of algae in pond water as well as one-celled animals. They are often quite large.

These three problems relating to the struggle for existence may be summarized in a chart showing that food for energy, growth, and reproduction is necessary for the continued existence of animals and plants.

For the teacher who wishes to teach more about reproduction, in answer to children's questions, the material in this chapter offers a natural approach. From a discussion of the reproduction of lower animals, it is a simple step to that of mammals. How far she should go depends on the attitude of the community, the school authorities, and her own background. Sex education can be a natural, normal, wholesome part of the science program if it is handled properly. It should not be set aside as a separate subject, so labeled. The teacher who wishes more information will find several good books in the reference list.

II. HOW SOUND IS PRODUCED AND CONDUCTED
(Pages 62–85)

This chapter continues and enlarges upon the concepts given in Book V. If the children haven't done the experiments suggested in that book, the teacher should let them do the simpler experiments before starting those suggested in this chapter. Having learned that sound travels in waves, the children will be ready to do the experiments on pages 64, 65, and 66. The children may read the experiments and do them as they read.

Problem A. How Does Sound Travel? (Pages 62–68)

Upper-grade children are old enough to begin to enjoy writing

up experiments. This shouldn't be a laborious process that takes the joy out of doing the experiment. They may follow a simple outline like this:

I. The problem.
II. The materials used.
III. How we did the experiment.
IV. What happened.
V. What we learned.

Also let the children suggest variations of the experiment. They will be able to give many examples of instances where sound travels through these different kinds of materials. Putting an ear against a telephone pole and listening to the hum of the wires is a common experience. Listening to the activities of woodpeckers in a tree is another common one.

In the experiment on page 65, be careful not to tap the glass tube or it will be carrying the sound instead of the soil. A long cardboard mailing tube is better to use and very easy to obtain.

If you are in a rocky region, the children should try making sound travel through large rocks.

Most children have tapped water pipes to communicate with other children somewhere in the house. If not, it is easily demonstrated in most school buildings.

The tin-can telephone will work for quite a distance if stretched tightly. A hard twisted twine should be used. Be sure that the children don't think that it is like a real telephone in the way the sound travels.

PROBLEM B. HOW ARE SOUNDS RECORDED? (Pages 68–73)

THE PHONOGRAPH

If an old phonograph is available, let the children take it to pieces and examine the parts. Find the part that vibrates. Compare it with the other vibrating objects the children have studied in connection with sound.

Experiment No. 1, on page 69, may not work very well as it is difficult to hold the cone steady with the finger. Try using the finger nail as a needle, holding the ear close enough to hear. This

is also true of Experiment 2 on the same page. But the children will get a pretty good idea of how the phonograph works by doing the experiments.

The modern recording machines in connection with radios are run by electricity and use the radio loud-speaker to amplify the sounds.

The experiences given on pages 70, 71, and 72 are described in more detail in the *National Geographic Book of Birds,* revised edition.

These scientists worked for ten years to perfect a microphone which would record the songs of birds and yet not record all of the other noises which are almost certain to occur in the native habitats of birds. They worked with different materials to try to get something that would absorb the disturbing sounds and reflect the bird calls. Dr. Allen is still recording bird songs, trying to get more unusual ones.

The records of these bird calls are on the market now and are well worth hearing. Teachers should try to get them and use them in connection with this unit. A bird does not have a larynx, as do human beings, but uses an organ called a syrinx, located in the lower part of the trachea. This apparatus may be obtained from a chicken, turkey, or duck, and examined to try to determine how sound is produced.

One group of children upon hearing these records wanted to record the bird calls on paper, in some way. They used dots and dashes similar to the ones used by Saunders in his book on bird songs. (See the reference list.) As the record was played the children tried to record each call. They used short marks for short notes, long ones for long notes, and showed the pitch by placing the marks on different levels. Such an activity helps children to listen more carefully to sounds.

SOUND THROUGH WATER

This experiment might be dangerous if a loud noise were made under water. If a pool is available, it may be done. In case a pool is not available, children will have to draw upon their experiences to illustrate the concept.

Problem C. Why Are Sounds Different? (Pages 74–85)

The children should bring various musical instruments to school to illustrate the ways in which musical sound is made. They should try to figure out what makes the sound in each instrument. If an old organ is available, take the back off and examine the inside as someone pumps it and plays. Compare it with the inside of a piano. An accordian may be examined, also.

Try the experiment on page 74 with different-sized rubber bands. A difference in sound will be apparent.

The experiment on page 75 helps to explain the way the pitch on stringed instruments is changed. The children should do the experiment and draw their own conclusions, then check with the text on pages 76 and 77.

Different kinds of whistles will help demonstrate the way sound is produced by wind. Discuss other sounds made by wind.

If test tubes are not available for the experiments on pages 80 and 81, glass tumblers or jars can be used. Pop bottles will work also. The children may discover that they can make sounds not only by blowing across the top of the open tube but also by using their fingers and making a popping noise by suction. By experimenting with different amounts of water in the tubes, the tones of the scale may be played. Since this takes quite a bit of time, it may be set up at home, or during free time at school, by children who volunteer. In one group, a boy whose school work had been poor, asked to tune the "water organ." He was allowed to take the tubes into a vacant room. In a surprisingly short time he brought them back in perfect tune, and played upon them. The psychological effect upon him was worth the time lost from the classroom.

To bend glass tubing for Experiment 4, a Bunsen flame or one as hot will be needed. As the tubing is heated, turn it constantly to prevent its breaking.

The tube used in Experiment 5 is open at both ends. The experiment helps explain all slide instruments.

In the experiment on page 83, the strip of cardboard used in No. 2 must be fastened inside the stem of the funnel so that it vibrates as it is blown.

While children will learn from their reading something about the way sounds are produced and varied, actual experiences with the instruments will give them much more understanding.

III. THE PLACE OF THE EARTH IN THE UNIVERSE (Pages 86–143)

This is one of the most interesting subjects to children but also contains the most difficult concepts for them to understand. Teachers have hesitated to introduce material on astronomy because of this, yet nothing so appeals to the imagination of sixth-graders. Perhaps all of them won't understand and learn all the concepts. If it adds to their idea of the vastness of the universe and the endlessness of space, if it answers some of the questions that puzzle them, it is worth while.

The topic may be introduced best when some astronomical event such as a comet, a shower of meteors, an eclipse, or an unusually bright planet display occurs. The completion of a new telescope may start discussion. Recently so many pictures of the new telescope at Palomar Observatory have appeared, that teachers should be able to find much bulletin board material. As winter approaches and the more brilliant constellations move into the night sky, many questions concerning them arise.

Problem A. What Is the Earth's Relation to the Stars? (Pages 86–105)

If night trips are not feasible, the teacher will have to use her ingenuity to help the children answer their questions. One group made big star maps by throwing the maps given in the monthly *Science News Letter* onto large pieces of paper with a reflecting lantern. Several worked together to trace the map on the paper.

Another group constructed a device to help them throw the constellations onto the ceiling. They made a tube of galvanized tin that just fit around the lens from an old lantern projector. They cut disks of cardboard to fit just inside the tube. They punched holes in the cardboard disks to represent stars in different constellations. By putting a light in the end of the tube opposite the lens,

they were able to throw enlarged constellations onto the ceiling. Each child made a disk with a different constellation to be used in the lantern. A similar device may be made from a cardboard oatmeal box and an ordinary light bulb. Punch holes in the lid to represent the stars in a constellation.

The accounts of stratosphere flights published in the *National Geographic* have excellent pictures of the balloons used and views taken from the stratosphere. Arithmetic will help the children estimate the distances discussed in this section. Sixth-graders can get a pretty good idea of a light year by estimating how long it would take them to travel that far in an airplane. Children get more ideas from this material than we sometimes realize. One child, after studying about the speed of light, remarked, "If you could get far enough away from the earth, you'd probably see dinosaurs still roaming around."

Be sure that children do not get the misconception that the stars are standing still. Because the stars keep their relative positions to one another, they are called fixed stars. Actually, of course, they are all traveling at a tremendous rate of speed.

If it is possible for the teacher to take the children on an evening field trip, late autumn is a good time to go. One group met at 7:00 P.M. at a park situated on a hill. Parents were asked to come with the children. For an hour they watched the stars come out, discussing each group as it appeared. They looked at the crescent moon through field glasses. Much interest was aroused in children *and* adults.

If a telescope is available, it is worth making the effort to let children look through it at the moon or some of the planets. Saturn is especially interesting when seen through the telescope. Children get a better idea of distance when they look at Jupiter or Saturn through a telescope. Both planets, which appear small to the naked eye, become glowing balls when enlarged.

To help children realize that gases are heated by pressure, let them use a pump and compress the air. They can feel the sides of the cylinder get hot. The things that are most difficult to understand are why the stars cool again after becoming white hot and why stars that are apparently dead suddenly flare up before going out entirely. However, since astronomers themselves do not under-

stand these things, children should know that many questions are yet unsolved.

The teacher should check all figures given in this chapter with the most recent textbooks on astronomy. As astronomers learn more and more about the stars, they change their opinions about their sizes and distances. All figures concerning the stars should be given as "What is known at the present."

This chapter affords excellent opportunities for teaching scientific attitudes. In the face of new evidence, men are continually changing their ideas about astronomy. Thus they have to be open-minded.

The word "constellation" is used here in its popular sense. Actually the pattern we see is a configuration. The constellation is the whole group of stars.

Stars are placed in magnitudes according to their brightness. First-magnitude stars are those which come out first at night and appear brighter than all of the others. The magnitude is the apparent brightness. Those visible to the naked eye are within the first six magnitudes. The brightest are first-magnitude stars, the faintest are sixth-magnitude. The following chart of the brightest stars and their distances in light years may be helpful to teachers:

Star	*Constellation*	*Common Name*	*Distance*
Sirius	Canis Major	The Dog	8.6
Vega	Lyra	The Lyre	26
Capella	Auriga	The Charioteer	50
Arcturus	Boötis	The Herdsman	40
Rigel	Orion	The Giant Hunter	600
Procyon	Canis Minor	The Lesser Dog	10.5
Altair	Aquila	The Eagle	16
Betelgeuse	Orion	The Giant Hunter	200
Aldebaran	Taurus	The Bull	60
Pollux	Gemini	The Twins	32
Spica	Virgo	The Virgin	200
Antares	Scorpio	The Scorpion	400
Fomalhaut	Pisces	The Fishes	24
Deneb	Cygnus	The Swan	700
Regulus	Leo	The Lion	60

An activity which will help explain the color of the stars may be carried out with a piece of wire. With pliers, hold one end of the wire in a flame and notice how the color changes from red to yellow as the wire heats. If it were heated with a blowtorch, the wire would get white hot. Let the children tell of experiences demonstrating this principle. Most of them know that the hottest flame on a gas stove is blue and that a yellow flame shows incomplete combustion. Some may have seen molten metal, and can tell how it turned yellow, red, then black, as it cooled.

The concepts of distance and speed of the stars may be clarified somewhat by using the facts given in doing arithmetic problems. Solving the problem at the bottom of page 94 will give a better idea of space than the figures alone.

After the children read about each of the constellations given on pages 96–104, let them locate each on a map of the entire sky. Since some of the constellations are visible only at certain seasons, different maps will need to be used.

Problem B. How Is the Earth Related to the Solar System? (Pages 106–121)

Although the planets have been studied to some extent in the lower grades, this problem attempts to orient the earth as a member of the solar system. If the children can project themselves out into space in their imaginations and try to picture the earth as it might look from the moon, they may be able to think of the earth as a globe.

The figures should be interpreted in terms of distances the children know. By discussing distances between points they have traveled and comparing them to the distance through the earth or around the earth, the figures mean more.

After children have gained some concepts concerning the size of the earth, they are better able to imagine the sizes of the other planets. Sometimes it helps for them to see how many balls the size of Mercury would go across the earth, or how a ball the size of Venus would nearly cover the earth. Then try putting balls the size of the diagram of the earth across the diagram of Jupiter to see how much larger Jupiter is than the earth.

One of the misconceptions that has spread generally is that Mars has people on it. The excitement caused by the Orson Welles broadcast a few years ago demonstrated that the general public was still suffering under that illusion. Of course we do not *know* much about the surface of Mars. The most powerful telescopes make it look about as big as a quarter. Imagine the earth the size of a half dollar. No one seeing the earth that size could tell much about it. Reduced to that size, mountain chains and rivers would look straight. Rough coast lines would also straighten out. Observers from such a distance would have little idea of the meaning of such lines. The same is true of Mars. The new telescope at Palomar Observatory may give us more information.

In teaching any of this material on astronomy, try to develop scientific attitudes. It is an opportunity to discuss theories, that is, ideas that people have which are based on evidence which have not been proved. Children should learn to be critical of everything they read and hear. They should develop a questioning attitude. The teacher can help develop this attitude by challenging them with such statements as this, "I read an article in the newspaper which said that all people born on this day have certain characteristics," quoting a horoscope from the paper. Then, "What do you think of this?" Astrology has a large following in the United States. It is difficult to believe that intelligent people still cling to mysticism and superstition, but many do. An examination of the numerous astrology magazines on the average magazine stand should convince a teacher of the importance of teaching children to think scientifically. It is certainly more important than merely filling their minds with facts that are meaningless to them.

When Jupiter is seen through the telescope, some of its moons are plainly visible. The number seen depends on their position in relation to the planet. Saturn is famous for its rings, which appear as a line, a halo, or tilted rings, depending upon its position. In any position, Saturn is a thrilling sight when viewed through the telescope. Let the children speculate as to the character of these planets, but check with an *authority* to verify any conclusions they may make.

A large bulletin board may be arranged as a summary, with circles cut from colored paper to represent the planets. Make the circles as nearly in proper proportion to one another as possible.

Problem C. How Do the Earth and Moon Affect Each Other? (Pages 122–132)

The moon can be seen quite well through good field glasses. Its surface will look something like the picture on page 123.

Since the moon is our nearest neighbor, we know more about it than we do about the planets. Telescopes make it appear large enough to be studied. Yet many people still have queer ideas about the moon and its effect upon the earth.

This problem offers an excellent opportunity to develop the attitude of believing in cause-and-effect relationships. Such superstitions as the ones concerning the effect of the phases of the moon on plant growth may be discussed. Teachers need to be careful about such a discussion. If a child says, "My father says that potatoes should be planted in the light of a full moon," the teacher will obviously not tell the child his father doesn't know what he is talking about. Instead she may say, "Many people think that. How can we experiment to find out if it is true?" Children may then plant various seeds or potatoes at different times, being sure to provide the same growing conditions for all of them. There must be enough experiments to prove something, for establishing wrong attitudes and concepts by drawing conclusions from insufficient evidence is as harmful as leaving the child with his original idea.

Children should go outdoors when the moon is visible in the daytime and observe how the lighted side is toward the sun. It is easier to see the moon as a sphere when it is in the first quarter than when it is full.

Even though in the lower grades the children have seen demonstrations to show the phases of the moon, the activities should be repeated. The teacher may ask if anyone knows a way of demonstrating the changing appearance of the moon on pages 126 and 127. If anyone does, he may be allowed to demonstrate it. Otherwise, the children may look at the pictures in The Seasons Pass and do the same demonstration. Encourage the children to observe the moon from night to night and draw it as they see it.

Eclipses happen somewhere every year. The minimum number is two, both of the sun. The maximum number is seven, five of the sun and two of the moon, or four of the sun and three of the moon.

Eclipses may be total or partial. Duration of a lunar eclipse is about three hours and forty minutes, and of totality one hour and forty minutes.

Total eclipses of the sun rarely exceed 7½ minutes. An annular eclipse may last a little longer.

These charts may help the teacher.

Eclipses of the Moon Visible in the United States and Canada During 1949

Date	*E.S.T.*	*Duration*	*Time of Totality*
1949 April 12	11:10 P.M.	3 hrs. 40 min.	1 hr. 30 min.
1949 October 6	9:50 P.M.	3 hrs. 30 min.	1 hr. 10 min.

Total Eclipses of the Sun, 1948–1979
Visible in the United States and in Canada

Date	*Duration in Minutes*	*Region*
1954 June 30	2.5	U. S. Great Lakes Region, Canada, Scandinavia, Russia, Persia
1963 July 20	1.5	Alaska, Canada, Maine
1970 March 7	3.3	Mexico, Georgia, Florida
1972 July 10	2.7	Northeast Asia, Northeast America
1979 February 26	?	Northwest States and Atlantic Ocean

Teachers will, of course, take advantage of any eclipse which may occur to help clarify children's concepts. Usually these eclipses are announced in the papers, over the radio, and in such magazines as *Science News Letter* and *Life,* far enough ahead of time to give people a chance to see them.

Tides are difficult phenomena to understand and to explain. An effort has been made in the text to make this simple enough for children to understand, but most children will need much help from the teacher. It is easy enough to understand the tide on the side of the moon, but it's the one on the opposite side of the earth that is puzzling. Water, being a fluid, bulges more than the solid portion of the earth. If the children understand that the tides *are* caused by the moon's pull on the earth and are something like a huge wave that moves under the moon as the earth rotates, that is about all we can expect them to comprehend.

The following demonstration may help to clarify the concepts.

Let a round balloon, filled with air, represent the earth. Hold

the balloon with one hand. That hand represents the earth's pull on itself. With the other hand grasp the opposite side of the balloon and pull. This hand represents the pull of the moon. The opposing pulls cause the balloon to bulge. While not strictly scientific, this activity is useful in helping to explain tides.

Children should observe the changing position of the same phase of the moon from month to month. This is due to the shifting of the plane of the moon's orbit.

Problem D. How Do Meteors and Comets Affect the Earth? (Pages 133–139)

Children often ask about "falling stars." Many adults do not realize that stars are too far away to enter our earth's atmosphere. This problem attempts to help children further enlarge their concepts of the size of the universe.

"Falling stars" are of course *not* stars. The nearest star to the earth beyond our own sun is over 24,000,000,000,000 miles away. If children figure how long it would take for one to reach the earth at even 1000 miles a minute, they will realize how improbable it is that the stars will hit the earth.

Meteors are pieces of rock or metallic stone that are traveling around the sun in large masses. They may be remnants of the materials drawn from the sun during the origin of the solar system, remains of exploding stars, or tails of comets. A recent theory is that they all come from a disintegrated planet.

When any of these particles come close enough to the earth to be attracted by its gravity, they are drawn into our atmosphere. Probably over 10,000,000 meteors are drawn into our atmosphere every day. Most of them are no larger than grains of sand.

As soon as these particles strike the atmosphere, their great speed causes enough friction to make them luminous. Most of them are completely consumed. A few are large enough to reach the earth's surface. These are called meteorites. Meteorite specialists say that these meteorites are more common than most of us suppose. A large number of meteorites have been found and studied. They have certain characteristics by which specialists recognize them. See the reference list for further information on meteors.

If possible, teachers should obtain specimens or take children to a museum to see meteorites. Good pictures may be obtained from the Hayden Planetarium in New York City. Many other museums publish pamphlets and pictures on meteorites.

Comets are not rare but very few of them are visible to the naked eye. Some of the periodic comets that have been studied are:

Halley's Comet last seen in 1910, returns in 77 years.
Tuttle's Comet returns every 14 years.
Tempel's Comet returns every 6½ years.
Biela's Comet returns every 6½ years.
Winnecke's Comet returns every 6 years.
Schwassmann-Wachmann's Comet, discovered in 1927, is thought to return every 16 years.
Encke's Comet returns every 3 years.

Within the last few years many new comets have been discovered but only a few of these are visible to the naked eye.

Comets are not very well understood. Their strange characteristic of beginning to glow and develop a tail as they approach the sun is interesting. The fact that the tail always points away from the sun seems to indicate that the sun has a repelling effect in some way. Scientists think that electrical energy from the sun bombards the head of the comet, pushing off particles from the head or nucleus of the comet, and causing it to glow from the absorbed energy. If this is true, the comet is gradually disintegrating. This may account for the fact that some comets have been seen once, then have disappeared.

Problem E. How Have We Learned About Heavenly Bodies? (Pages 140–143)

The new telescope at Palomar Mountain has caused so much popular interest that many children will have heard of it or seen it. One group, after listening to the description of the huge lens, by a child who had seen it, wondered how big a 200-inch lens would look. They measured 200 inches on the floor and made a circle with the chalk mark as its diameter. This gave them a concrete idea of the size.

A simplified story of Galileo is very interesting to read in connection with this problem. Sixth-graders may study lenses and discover how they may be combined to bring the stars nearer. They may read about the first telescope and draw a diagram of how it must have looked.

To understand the way a lens works, let the class experiment with hand lenses. Darken the room and hold a lens in the path of a beam of light coming into the room through a hole in the shade. Shake some chalk dust in the light, and the crossing of the rays will be clearly visible. If one person holds one lens, focusing the light, and another holds another lens in the light beyond the first lens, the rays will be redirected.

Teachers will enjoy reading *The Star Gazer,* and telling the children about parts of it. A discussion of the attitudes of people during Galileo's life as compared with ours of today will develop appreciation of the changes science has made in human thought. Although in some parts of the world intolerance is still very evident, scientists are not imprisoned for their discoveries.

A good summary for this problem might be a comparison of ancient ideas concerning the universe versus those we have today. This might take the form of reports, a program, a dramatization, an exhibit of drawings and models, a book, a chart, or a bulletin board. The subject is flexible enough to admit of any techniques the teacher wishes to use. As long as the children set up and solve their own problems and develop scientific attitudes, the materials they use may be varied. Be careful not to carry it beyond the abilities and interests of the group. Use enough illustrative materials to make it as real as possible, and appeal to the imagination enough to help children visualize what they are talking about. Continually bring in their own experiences and encourage them to observe the sky. Remember that much knowledge still is not revealed to the scientist, and be willing to learn with the children. Keep open-minded and instill in children the same attitude. Preface statements with, "As far as scientists know, this is true." This isn't the kind of material in which we can say, "We *know* all of the answers"—all of which makes it more stimulating and challenging.

IV. SOME MINERALS IMPORTANT TO MAN
(Pages 144–167)

An interest in rocks and minerals may originate with the finding of fossils, some clams or snails that have died and left their shells in the aquarium, some buildings that are going up in the neighborhood, or the manufacture of cement. There are numerous ways in which an interest in minerals may arise naturally.

One group saw the patterns in some red sandstone that was being used for steps in the new library. The children thought the patterns were fossil ferns and were surprised to learn that they were mineral deposits resembling ferns.

Another group brought to school pieces of limestone that were being used to clarify sugar in a sugar-beet factory. One group had several members who had visited Carlsbad and brought back stalactites to show the class. Most children are interested in rocks and want to know something about their origin. Since the materials of the earth are everywhere, there is always plenty available to help in the solution of problems.

A field trip may be taken to find as many different kinds of rocks as are in the region. The teacher might stimulate such a trip by showing a rock she had picked up, telling why it interested her. She might say "I wondered where this rock came from. There were no others like it along the road. Have any of you found one like it?" Following a discussion she could take the class outdoors to find rocks, or suggest that they bring rocks to school.

Scientifically, a rock is any solid part of the earth's crust. Rocks are made of minerals. A mineral is a natural, inorganic compound. It is part of rock but is more specific. For example, sandstone is a common rock. It is composed of grains of sand cemented together. The sand is small pieces of quartz, a mineral. The cementing material may be iron oxides, lime carbonate, clay, or a mixture. Yet a large piece of quartz would be a rock, since it is a solid part of the earth's crust. If the teacher hasn't enough background in chemistry to understand the reactions in Problem A, the manual for How and Why Experiments will help her.

Problem A. How Is Limestone Important to Man? (Pages 144–155)

Children should be encouraged to bring in all kinds of building stone. They may first separate the stones into those that are hard, the ones that seem to have sand in them, and those that are smooth and smell like mud when breathed upon.

The teacher should collect as many different kinds of limestone as she can find. $CaCO_3$ is the chemical formula for calcium carbonate. Ca stands for one atom of calcium. C means one atom of carbon and O_3 means three atoms of oxygen. HCl is hydrochloric acid, commercially known as muriatic acid. H is hydrogen and Cl is chlorine. CO_2 is carbon dioxide. Let the children learn the test for $CaCO_3$ by putting drops of dilute HCl on a piece of pure limestone. Marble will show the typical reaction. After learning the test, the children should be allowed to test any rocks that look like limestone. The conclusive test is one drop of cold, dilute HCl on the solid lump. If the rock is limestone, it effervesces. CO_2 is released by the reaction. The proportion of acid to water is 1:4.

Most stalactites and stalagmites are $CaCO_3$ but a few caves are lined with crystals of other minerals. Fluorite is one mineral that sometimes forms stalactites. The test will determine if the crystal is $CaCO_3$. Dogtooth Spar is the name commonly given to calcite crystals. Iceland Spar is an interesting form of calcite that has double refraction. It is clear, like glass, but lines look double through it as in the picture on page 152.

In the picture on page 153, the numbers correspond to the following names:

1. Shell conglomerate
2. Flint nodule covered with chalk (Flint is deposited in chalk beds.)
3. Marble
4. Marl
5. Calcite crystals
6. Fossil-bearing limestone
7. Lithographic limestone

Children should test shells to discover that there is $CaCO_3$ in them. They may test the deposit from the bottom of a teakettle to

discover that lime in water may be deposited in the form of $CaCO_3$. They may clean the white deposit from the inside of vases or drinking glasses with dilute acid. They may put a pearl button into acid to discover that it is made of $CaCO_3$. Imitations are often made of plastic.

If a clam, oyster, or snail shell is baked, it can be broken and the children allowed to examine the layers. The inside layer is mother-of-pearl and is $CaCO_3$ secreted by the body of the clam. The next layer, also secreted, is the prismatic layer made of $CaCO_3$. The outside layer is organic material, something like skin, and doesn't react to acid.

A clamshell immersed in acid until all of the $CaCO_3$ has been dissolved is limp and rubbery. The animal matter remains. A hen's egg put into acid shows a similar reaction. A chicken bone put into acid will also demonstrate the presence of $CaCO_3$ and that the bone would be soft without the $CaCO_3$.

Some "chalk" used on blackboards is $CaCO_3$ while some is manufactured. Children should test it to find out which it is.

Lime is not the same as $CaCO_3$. Lime is CaO and is soluble in water. If it weren't soluble, animals would not be able to assimilate it and use it in making the insoluble $CaCO_3$. Dissolved in water, lime becomes calcium hydroxide which reacts with carbon dioxide to form insoluble calcium carbonate. If the children have studied carbon in the fifth grade, they will be familiar with this reaction in the limewater test for CO_2. Chalk is the precipitated form of $CaCO_3$.

In the formation of caves, weak carbonic acid formed by the union of CO_2 with rain water, seeps through the earth and dissolves $CaCO_3$ from the layers of limestone. After the cave has been made, more water seeping down drops from the roof and as it evaporates leaves $CaCO_3$ behind in the form of stalactites. Some water drips on the floor of the cave and builds up stalagmites. Stalactites and stalagmites differ in appearance in that the former grow in concentric circles, while the latter spread out in layers like a cake.

If children have no opportunities to visit caves, moving pictures or slides of caves will help them to understand how caves look. Lacking these, magazine pictures are often very realistic.

The formation of pearls is described in detail in encyclopedias and in magazines like *Natural History* and *National Geographic.* Children living on the coasts should take a trip to the beach to find shells and shellfish. The teacher may go as far as she likes with related problems.

PROBLEM B. HOW IS QUARTZ IMPORTANT TO MAN? (Pages 156–160)

In the primary grades, the children studied about quartz and its use to primitive man. This problem introduces the use modern man makes of quartz. It also shows how another carbonate is used by man.

If the children don't know about quartz, they should learn how to recognize it by its typical fracture and its hardness. These are discussed on page 159. Some form of quartz is common in almost every region.

No matter what color a large piece of quartz may be, when it is pounded to a powder the powder is white. This powder of a mineral is called its *streak* and is one way geologists identify the mineral.

When boys discover that an agate is a form of quartz, they want to test their marbles. They discover that glass marbles can be scratched with a steel file or knife while real "aggies" cannot be scratched. The characteristic fracture of quartz when it breaks also explains why their aggies chip in half moons.

If the materials are available, the teacher may demonstrate glass-making to the children. Make a platinum needle by inserting a piece of platinum wire, about two inches long, into the red-hot end of a piece of glass tubing. The glass tubing makes a handle. Bend the end of the wire to form a loop. The materials needed are some washing soda and fine white sand.

Heat the loop red hot in a flame. Dip it quickly into the soda. Heat the bit of soda in the flame until it melts and forms a liquid bead. Quickly dip this hot molten soda into the sand. Once more hold it in the flame. The sand grains will boil in the hot soda, finally dissolving in it. When the sand has dissolved, let it cool and you will have a bit of glass. If you wish to color the glass,

again dip it into some iron filings or liquid cobalt and heat in the flame. Different minerals produce different colors.

If a clear crystal of rock crystal is found, show how it acts as a prism to separate sunlight into the colors of the spectrum. Compare the spectrum with that made with a glass prism, by making the two spectra at once.

Many magazine articles on the use of quartz crystals in radios appeared during the war. These had many pictures which teachers will find useful in teaching about quartz. *Life, Natural History, National Geographic, Science Illustrated,* and *Science News Letter* are some of these magazines.

Since forms of quartz are used in jewelry, the girls will be interested in finding moss agates, amethysts, rose quartz, and chalcedony. In some parts of the United States these are very common. If the school shop is equipped for polishing and cutting stones, ornaments may be made from them.

An answer to the question of why the aquarium gets scratched when it is washed is given in this chapter. Moral—rinse out all the sand before washing the aquarium.

Problem C. How Are Gold, Silver, and Copper Important to Man? (Pages 161–162)

Children often bring in pieces of iron pyrite and think it is gold. "Fool's gold" is the common name for it. Minerals known as the metallic minerals usually occur in the form of ores.

Most families have samples of ores of some kind in their collections. When they learn that Johnny is studying about minerals, it is surprising how many specimens will appear.

This topic integrates ideally with a study of natural resources. The children may make maps showing the regions in the United States where different minerals are found. They may study mining and ways that minerals are obtained from the ores.

If you live in the region where native copper is mined, you can probably obtain some of the ore. The children can dig pieces of copper out of the rock with a knife or file, and pound it to make it stay together. They can demonstrate the conductivity of copper by

connecting the terminals of a battery with a piece of the copper and ringing a bell.

With a little apparatus, lead can be obtained from galenite or galena, as it is commonly called. Crush a small piece of the ore and put it into a test tube. Heat in a flame until the impurities are driven off. A small drop of lead will remain. A gas flame is needed for any experiments with ores, or a flame as hot as gas. If an elementary science room, equipped with Bunsen burners, isn't available, the teacher may be able to use the high school science room.

Children should discuss the ways in which all of these minerals are used by man. They may make a list of all of the things containing these minerals. They will notice that one difference between the metallic minerals and nonmetallic ones is their weight. Metallic minerals also have a metallic luster that makes them look different.

Problem D. How Is Iron Important to Man? (Pages 163–167)

Iron is one of the commonest metallic minerals.

Combined with water and oxygen or oxygen alone, iron colors our soil, our rocks, and in some places our streams.

If you live where the water is often colored yellow or red, you can demonstrate the way bog iron ore was formed. Simply let some of this colored water stand until the water has evaporated. The deposit left on the bottom of the jar is limonite or hematite. This iron, of course, comes from rusting pipes. In a bog it comes from water that has flowed through iron-bearing rocks.

Limonite may be heated in a test tube and some of the water driven off. It will condense on the sides of the test tube. If it is heated in a hot enough flame long enough, the powder will turn red, showing that it has been reduced to hematite.

Hematite may be reduced to magnetite by heating it very hot on a piece of charcoal. This is dangerous to try in the ordinary classroom. If a science room is available and the teacher wishes to demonstrate the reduction of iron ore, this is the way it is done.

Make a blowpipe by heating the end of a twelve-inch piece of

glass tubing until it is red hot. Draw the end out to a point and break it off. Heat the tubing again about three inches from the point, and bend at a 45° angle. Cool.

Obtain a stick of charcoal about six inches long, two inches wide, and an inch thick. Make a small depression near one end in which to place the piece of hematite. Hold the opposite end of the charcoal in one hand; use the other hand to hold the blowpipe. Direct the flame of a candle onto the piece of hematite, with a constant stream of air from the blowpipe. Be careful not to suck in on the tube. It takes a little practice to get a steady, hot flame.

The teacher should do this as a demonstration. Although children who have learned laboratory skills and used them for several years *can* do this experiment safely, it is not recommended as an individual activity. If the teacher thinks her class can do it, she should go over the safety rules with the children, calling attention to the particular dangers involved in this experiment: handling of matches and candle; hair that may catch fire if it isn't tied back; gas which may be inhaled if one sucks instead of blowing on the blowpipe; burned fingers if one touches the hot glass, charcoal, or ore. Forceps should be available for handling these. All work should be done on a metal tray or table top. Water should be within reach of everyone. No paper or other inflammable material should be near the candle.

The newest theory that physicists are giving to explain the difference between magnetized and nonmagnetized iron involves the behavior of electrons. It is too difficult for sixth-graders to understand. The explanation given on page 166 is much simplified but is not incorrect. The end result of the behavior of the electrons is to cause each molecule to act like a tiny magnet, lined up S ends to N ends.

Magnetized magnetite is called lodestone. The teacher should try to obtain a lodestone to show to the children. By dipping the magnetite into iron filings and holding one end of a bar magnet near the lodestone, the poles of the magnetite may be located. Or it may be held above a floating magnetized needle to discover which side attracts the N pole of the needle. When they see that a chunk of magnetite has poles, just as a bar of steel does, children can more easily understand about the magnetic poles of the earth.

The function of iron in the body is more easily understood following an experiment showing the oxidation of iron.

Prepare some oxygen by pouring one-fourth cup of water into a large jar containing an ozone cube (sodium peroxide). See the manual for How and Why Experiments for explicit directions. With forceps, hold a piece of steel wool in a flame until it glows. Then thrust the steel wool into the jar of oxygen. It will burst into flame, showing that the iron and oxygen have united. Of course, the iron in the body doesn't burst into flame, and it isn't in the form of steel, but the experiment shows how iron and oxygen attract one another.

Another simple experiment shows slow oxidation of iron. Put the piece of steel wool into a saucer containing a small amount of water. Invert a jar over the steel wool and let it stand for several days. As the steel wool rusts, water will rise in the glass, showing that something from the air is being used in the rusting process. To learn if this was oxygen, quickly put the jar over a burning candle. If oxygen remains in the jar, the candle will burn a few seconds before going out. Any form of iron such as nails may be used for this experiment.

When the hematite has been reduced to magnetite, you can pick it up with a magnet. Magnetite is one of the oxides of iron.

This study of rocks and minerals may be summarized by making an exhibit of rocks and minerals found in the community, with some of the uses of each shown by products or pictures. One sixth grade was studying castles in social studies, cathedrals in art, and building materials in science. They summarized all three in an assembly program illustrated with their work.

Another class, in a region where fossils were often found, made a large diagram of a building. They called this the Museum of Time. On a table in front of the board they put fossils, both ones they had found and others loaned to them. A string led from each fossil to a floor of the museum. The bottom floor was the most ancient, the top most recent. No attempt was made to give names to the ages or specific names to the fossils. They were classified as coral, sponges, trilobites, fish, and so on. There are several good sources of information for teachers in the reference list.

V. THE WORK OF THE WEATHER BUREAU
(Pages 168–192)

Children have a spontaneous interest in the phenomena of weather. Little children wonder about rain, snow, wind, rainbows, and other obvious manifestations which affect them. Older children hear weather predictions and wonder how they are made. If a consistent science program has been followed from kindergarten through the grades, by the time the sixth grade is reached children will know the basic concepts necessary to the introduction of these problems. If the teacher discovers that the children do not know these concepts, she should begin with some of the experiments given in the lower grade books and build up to this one.

Some of the concepts children will have to know are:

1. Air exists and takes up space. It is all around us.
2. Air expands when it is heated and contracts when it is cooled.
3. Water evaporates when it is heated and condenses when it is cooled.

See the manuals for the lower-grade books of this series for activities developing these concepts.

The subject may be introduced by a discussion of why weather changes are important. A sudden change in weather will provide an opening for the teacher to say, "Why do we listen to the radio weather forecast?"

Problem A. Why Does the Weather Change? (Pages 168–180)

Suggested Activities:

If a pool or other body of water is accessible, the children should take the temperature of the water, of an adjacent land area, and of the air. Note the difference in the temperature of the three media.

An experiment with a convection box will help demonstrate the concept. A tin box is best for this. Make two holes in one side of the box. Replace the lid with a piece of glass. Lay the box on its side and put a lamp chimney over each hole.

Mount a candle in the box under one hole. Light it. Hold a piece of smoking punk or incense over the other chimney. A tight roll of corrugated cardboard makes good smoke. Be careful not to heat the air in the chimney with the smouldering material. The smoke will be carried down the cold air chimney, across the box, and up with the warm air. Convection currents are currents set up in air or water by unequal heating. As many examples of the application of this principle as the children can think of should be discussed, such as hot-air furnaces, air currents around a bonfire, and currents around stoves.

Children should observe and discuss different kinds of clouds and the weather associated with them. While cloud types cannot be used alone to predict weather, they help interpret the conditions of the atmosphere. Aviators learn to predict weather quite well by clouds, but they have a larger area to predict from.

Even though experiments demonstrating evaporation and condensation have been performed, it is a good idea to do them again. If a piece of dry ice is available, put it in a tin cup or aluminum pan, and watch the frost form on the outside of the cup.

A simple way to demonstrate fog or cloud formation uses a quart milk bottle, hot water, and an ice cube.

Fill the milk bottle a quarter full of hot water. Lay an ice cube across the top of the bottle. As the water evaporates from the hot water and reaches the cold area around the ice cube, a cloud is formed. A ball of snow may be used instead of the ice cube.

To demonstrate the way snowflakes are precipitated from the air, make a hot, saturated solution of boric acid in a jar. Immediately set the jar into a pan of snow or in a cold breeze. The sudden chilling will cause a shower of crystals to be precipitated out of solution. It will look a little like a "snowstorm" of boric acid crystals. Snowflakes are formed when the temperature of saturated air drops below freezing. The water is precipitated out of solution in the form of ice crystals which move together around a nucleus of dust to make the patterns of snow. Even though sixth-graders have probably seen snowflakes through a lens, they should be given the opportunity to do so again.

To actually see water crystallizing, put a layer of ice and salt in the bottom of a large glass jar or bowl. On this ice stand a thin

glass tumbler filled with water. Pack more ice and salt around the tumbler, leaving a space on one side through which to observe. The crystals will "grow" from the sides in toward the center of the water. This illustrates the principle that crystals have to have something to form around or upon.

Questions often are asked about so-called "air pockets." This term is used in describing unfavorable flying conditions. The air pocket is an area of pressure differing from the surrounding air layers. When airplanes strike such an area, the result is like striking a hole in the air. It is an area of lower pressure.

The way that colder, heavier area settles to the earth and pushes up the warmer, lighter air might be illustrated by pouring a denser liquid into one less dense, such as water into oil, or molasses into water.

The air mass theory of air movements is described in the newer meteorologies. Teachers should read a good, recent authority on the subject and not try to teach children more than the simple concepts necessary to answer their questions. Sixth-graders are old enough to learn that scientists have theories. All truth is not known, and we are constantly changing our minds as new evidence is gained.

If the class is interested in aviation, maps and charts may be obtained from the airlines and other sources listed in the references.

A simple way to help children get the idea of the reason winds start whirling is to put a chalk mark on the floor to represent a heated area on the earth's surface. Have the children form a circle around the mark. Let them all start toward the center to show the way the air currents move as the colder surrounding air moves in under the warmer air. This represents the way the winds would blow if the earth were standing still.

Then have the children imagine they are all pulled slightly to the right as they move toward the center. This will make them start walking in a spiral, counterclockwise direction in relation to their neighbors. With the high, the children will all start from the center and walk away from it. Once more veering to the right they will find themselves walking clockwise.

Collect pictures and clippings to illustrate tornadoes and hur-

ricanes. If either is common to the region, ask an authority to talk to the children, explaining the causes, conditions preceding the storm, and what to do in case of a storm.

PROBLEM B. HOW IS WEATHER FORECAST? (Pages 181–192)

The class might make a collection of old weather sayings and check them with the weather over a period of time to see if they are true.

Simple weather vanes and rain gauges are easy to make. The group can keep a record of the wind directions and amount of precipitation with these.

A simple rain gauge can be made with a funnel and a tall jar. By measuring the area of the top of the funnel and the bottom of the jar you can get the proportional amounts of rainfall.

The class should use thermometers and keep records of readings in various places at different times of the day. They will find a difference in the temperature of snow and the air above it, in the sun and shade.

To demonstrate the way an anemometer works, fasten paper cups to sticks as shown on p. 185. The cups may be thumbtacked to the crossbars.

A simple hygrometer (wet and dry bulb thermometer) for measuring relative humidity is easily made. Get two thermometers that read the same. Fasten a lamp wick or piece of cheesecloth around the bulb of one. Keep one end of the cloth in water. Both thermometers should be placed on the same side of the room. As water is absorbed by the cloth, it climbs by capillarity to the part around the bulb. As this evaporates, it cools the surface of the bulb and the temperature drops. The dryer the air, the more rapid the evaporation. Thus the more difference there is between the readings on the two thermometers, the lower the humidity in the room. To compute the relative humidity one has to have a chart for that purpose. See Craig, *Science for the Elementary School*, p. 217.

Directions for making a barometer are given in the manual for Book V. In January, 1940, the U. S. Weather Bureau introduced the millibar as the unit of measurement to be used on all weather

maps. Most maps have the isobars marked in millibars at one end, in inches at the other end. The reason for the change was that inches measure distance while millibars measure pressure.

Weather maps may be obtained from your nearest Weather Bureau station. They are usually about 20¢ a month. Children may study them and post them on the bulletin board. They may practice forecasting weather by their own instruments. Then compare their forecasts with those of the U. S. Weather Bureau.

If the high areas are colored yellow and the lows black, the maps make an interesting border around the top of the board. If placed in sequence, lows may be followed across the United States.

One group summarized weather study by having a quiz program to which they invited two other classes. As the boy or girl was given a question to answer, he or she proved the point by an experiment or demonstration. For example in answer to the question, "What causes winds?," the child answered by performing a convection experiment and explaining how it applies to winds.

This material has many possibilities for integration with social studies. The effect of weather on climate, on peoples, on surface of the earth, and upon large bodies of water may be brought into the discussion. A group book on weather and climate may be made, including pictures, records, sample weather maps, newspaper clippings, and other interesting material. Such a book would be useful if placed in the school library for other children to examine.

The answers to the questions given on pages 191 and 192 may be:

1. The weather records for a few years would tell a doctor which places in the United States have the most sunshiny days and dry air.
2. Weather records would help fishermen to know where fish would have the best conditions under which to breed and grow, and where fishing would be most pleasant.
3. The owner of a greenhouse would need daily weather reports to know how to regulate the temperature and humidity in his greenhouse.

4. The fruit grower also needs daily reports to know how to avoid freezing or spoiling of his fruit.
5. The contractor, knowing that rain or other storms were predicted, would try to get the roof finished.
6. An engineer designing a bridge or skyscraper needs to know the average wind velocity of the region. For the bridge, he also needs to know the flood conditions of the river.
7. The silk manufacturer needs to know about the relative humidity of the place where his factory will be built. So does the candy manufacturer.
8. The insurance man needs the records of tornadoes, hurricanes, hail, and lightning in the region before insuring property against these things.

The daily weather chart may be a cooperative one on the school bulletin board. Each grade may contribute to some part of the record, with the sixth grade directing the activity. The morning radio prediction might be posted each day. One sixth grade, with a sense of humor, supplied a cartoon each day illustrating their prediction. Another class had a clever comment for the heading of each day's prediction.

VI. ENEMIES AND FRIENDS OF HEALTH (Pages 193–218)

Problem A. What Are Some of the Dangers to Health? (Pages 193–201)

This chapter helps to answer many questions asked by children of today. The teacher may use her own judgment concerning whether or not to include it in her science teaching. The author feels that introducing the subject of stimulants and narcotics to children who have never come into contact with them and who are not old enough to be affected personally, might be like the results of the story of the children who put beans in their noses! In many communities this topic is not a problem. In that case it might better be postponed until children are in high school.

If, however, children ask questions or show an interest in drinking, smoking, or drug addiction, they should have a source of in-

formation. Their problems should be set up as science problems and all the data available be gathered before drawing conclusions. Many magazine articles have been written on experiments with alcoholism and smoking. Since many parents both smoke and drink in their own homes, the teacher will need to use tact in handling the material. It should be treated as a science problem, not a moral one. The facts which have been gathered by experimentation should convince children that all of the drugs discussed are harmful to health.

Problem B. How Does X-ray Work? (Pages 202–204)

Most children have had some experience with X-ray and are curious to know how it is possible to see through flesh. It may help them if they review some of the experiments they have performed with light in the lower grades. They discovered at that time that some objects were opaque, some translucent, and some transparent. They have also learned that a single cell allows some light to pass through it, when they examine it under a microscope. Flesh is made up of masses of cells. If children hold up their hands near a strong light, in a darkened room, they can see light through the skin between their fingers. In the aquarium they can see light passing through the bodies of small fish while the bones look like shadows.

X-ray is a more powerful ray than light rays. In the spectrum the red rays are the longest rays. They do not penetrate the skin. The violet rays are the shortest rays and go deeper. At both ends of the spectrum are energy rays not visible to the human eye. The infra-red are longer than visible red, and affect the skin as heat. The ultra-violet are shorter than violet and penetrate the skin below the sensory nerve endings. One does not sense or feel ultra-violet. Consequently the rays can cause a severe burn before one realizes it. At high altitudes, where the sunlight may not feel hot, people are often severely burned by the ultra-violet rays. The thin atmosphere dissipates heat quickly so that the air is cool and the person may actually feel cold, yet be sunburned.

X-ray is shorter than ultra-violet, having therefore a greater fre-

quency and more penetration. There are different degrees of X-ray, the longer ones being known as soft. These will penetrate flesh. The shorter ones are known as hard, and will penetrate metals. Hard X-rays are widely used in industry.

Radium, uranium, and other radioactive minerals emit rays even shorter than X-ray. Therefore they are more penetrating. All of these rays beyond the violet are very powerful and can be dangerous if not properly used. Cosmic rays, that come into our atmosphere from outer space, are the shortest and most powerful of all. Scientists know little about them but are trying to discover more all of the time. A recent theory states that cosmic rays affect the human body favorably and may be partially responsible for the rugged health of individuals who lead an outdoor life.

If it is possible to visit a clinic or hospital X-ray department, the teacher may arrange to have the radiologist explain the machine. He will probably be glad to show some X-ray pictures, also. Usually some films may be borrowed from a local doctor to use in a class.

Problem C. How Are Diseases Caused and Cured? (Pages 205–218)

This topic summarizes some of the concepts of disease and enlarges upon them. The word "germ" was introduced in the first grade to designate any invisible organism causing disease. "Germ" is not a scientific term but since it is a popular word used in this connection, it has meaning for a six-year-old.

By the time a child is old enough to use a microscope and to know that there are living things too small to be seen with the naked eye, he can learn about bacteria, yeasts, and molds. Some of these are responsible for disease and in the fourth and fifth grades the children did some experiments to help them understand these micro-organisms.

Now, children are old enough to further enlarge their concepts of the causes of diseases. They are extremely interested in their own bodies. Most of them have had some diseases caused by micro-organisms. Many have been given some of the new drugs.

The topic usually arises very naturally. Someone is ill with a sore throat, influenza, or other infection. A child is sent home with a cold. The school children are all given toxin-antitoxin. The March of Dimes or Tuberculosis Seal Drive is on.

If the children wish to experiment with micro-organisms, some of the activities suggested in the teacher's manual for How and Why Experiments may be carried out.

Sixth-grade children are often interested in testing the validity of advertising. After growing some micro-organisms on gelatin or agar cultures, let the class put a few drops of different "antiseptic" solutions on different colonies of bacteria or molds. Again allow the cultures to stand in a warm dark place. It is a proved fact that most of the highly advertised antiseptics do not even inhibit the growth of bacteria. This activity teaches the scientific attitude of critical thinking.

In connection with the study of tuberculosis, a survey of the community milk supply may be made to learn whether or not all cows are tuberculin tested. In regions where undulant fever is a problem, the class may find out if the herds are tested for Bang's disease. In the picture at the bottom of page 210 the bacteria are rod-shaped. The round masses are tissue cells.

The electronic miscroscope has made visible the tiniest of disease organisms, the viruses, and is being used to learn more about them. This microscope acts much like X-ray, not like an ordinary microscope. The shadow of the enlarged object is cast on a screen and the observer sees the shadow. Many pictures of bacteria and viruses have appeared in magazines, so the teacher may be able to find some to show the class. The bacteria look immense compared with viruses.

Many children are familiar with ringworm or athlete's foot and are interested to find out what causes them. If the school has a swimming pool or showers, athlete's foot may be a problem. The school nurse or a doctor should talk to the class and give instructions on preventive practices.

It isn't important that children know a great deal about the new drugs other than that they are powerful and should never be taken unless prescribed by a doctor. More of these new drugs are being developed all of the time. Several from molds are being

used in experiments upon such diseases as tuberculosis. These drugs from molds are not the mold plants but are substances produced by the molds as they grow. They have been especially effective in the treatment of pneumonia and pus-producing bacteria, but they are not cure-alls. Some people are allergic to molds and can't take the drugs.

All through this chapter, the stress should be placed upon preventing disease rather than curing it.

It is hard for us to imagine the amount of suffering that has been relieved by the various kinds of anesthetics. Many twelve-year-olds will have experienced some type of anesthesia and can describe the sensations one has when the nerves are deadened in some way. The important idea in this section of the book is to teach appreciation of the service rendered to humanity by scientific research. The teacher may go as far as her judgment leads her in the use of illustrative material.

VII. THE CONSERVATION OF WILD LIFE
(Pages 219–250)

The problems under this topic may arise in many ways. They presuppose a background of knowledge based on the other books in this series. The concepts gained in the first chapters of How and Why Discoveries are enlarged upon in this chapter.

In the introductory discussion the children should list reasons why they think prehistoric animals became extinct. Then list reasons why animals of today have survived. They should discuss the questions given at the top of page 219.

Problem A. How Do Animals Protect Their Young? (Pages 219–222)

This problem summarizes and gives an opportunity for comparison of types of animal reproduction previously studied by the children.

It should be brought out that the lower the animal, the more eggs it produces and the less care it gives to the eggs or young. Since there is less chance for survival the species would probably become

extinct if the animal didn't reproduce in large numbers. Children should be given as many experiences with animals as possible.

A good way to demonstrate this principle is to count the number of eggs laid by one spider, one frog, or one fish, and imagine what would happen if they all hatched and grew to adult life.

Problem B. How Do Animals Get Enough of the Right Kind of Food? (Pages 222–224)

The children should name animals that live in their region and discuss the ways they get enough food.

Years when we have insect plagues, such as a grasshopper plague, animals which feed upon them often move in after the insects. If these enemies of the insects are encouraged, the insects may be exterminated. Then the enemies move on.

Migration and hibernation are not done for protection, but they act as protecting factors in the lives of the animals which practice them. Possibly those animals which did hiberate or migrate survived while others of the same family didn't.

The children should realize that of the large number of lower animals produced each year, very few survive. Also that the life of any wild animal is a constant struggle for food. If one watches any wild animal for a while he will be impressed with the fact that the animal is continually hunting food. A field trip to look for the tracks of animals is one way to learn about the feeding habits of these animals. Many animals hunt for food at night and leave their tracks in snow, mud, or sand.

Problem C. What Are Some of the Enemies of Wild Animals? (Pages 224–228)

Most children have seen dogs drive other dogs away from food, or they have watched birds at a feeding tray. They may make diagrams showing the food relationships. For example, man eats fish, and fish eat smaller animals or plants, which in turn may feed upon microscopic life.

One class made a large pond cross section with pictures of all the life in the pond. They connected each animal with its food by

strings. Another group made diagrams of scales with the kind of animal on one side and the enemies on the other side of the scales. Children will think up many ways to show the balance between life and the forces destroying it.

If the destruction of wild life by man is added to the side of the scales with enemies on it, the children will see how overbalanced the scales become. The class should investigate local wild life destruction. One group discovered that a local paper factory was dumping dye into the stream flowing past its doors. The dye was killing thousands of fish. While the children couldn't do much about it, they learned a great deal by their study. Eventually the people of the community were aroused and the practice stopped.

It is true that laws permit hunting of animals at certain seasons and we do not wish to be sentimental about the killing of animals. Even conservationists admit that in certain areas protection of deer, elk, or other wild animals may increase them to the point where some should be killed. This is done in accordance with laws.

Problem D. How Does Man Protect Wild Life? (Pages 228–233)

Children should investigate the laws of their own state to learn what protection is given by them. They should find out about parks, sanctuaries, and other refuges for wild animals in their state. They may make maps showing the national parks and put in names or pictures of the wild animals protected there.

In a small way school children can protect the wild life in their own regions. By learning not to break limbs from trees and shrubs, how to observe birds and other animals instead of killing them, and to collect only things they are going to use or care for, children are practicing conservation. They can make feeding shelves for birds and provide winter food and water.

Problem E. How Do Water Birds Survive? (Pages 234–250)

This problem contributes to the concept of animal adaptations. In The How and Why Club, the children learned how wood-

peckers are fitted for the life they lead. In the fifth-grade book, they learned about adaptations of birds of prey. This book shows how water birds are able to survive.

Nearly every region has some water birds, if only during migration. Even the arid regions of the west have great flocks of water birds lighting on irrigation reservoirs and fields to feed during these migrations. A few, like the killdeer, are common to every farm boy and girl. Yet many adults have lived near these interesting birds all of their lives and know nothing of them or their habits.

Bird study is a phase of science that leads to hobbies and leisure time pleasure. It is a hobby which may be pursued alone after very little formal introduction. Also if attacked from the standpoint of interesting habits rather than mere identification, it justifies itself in desirable outcomes.

Sixth-grade boys are apt to look at birds with an eye for the sport in killing them. If the teacher can arouse an interest in watching birds and keeping records, she may change the boys' attitudes.

Actual observation of these birds is the best activity to use in answering questions concerning adaptations and habits.

Wading birds are characterized by long legs, pointed beaks fitted for fishing, and moderately long necks. This nontechnical group includes deep waders such as herons and bitterns; shallow water waders like the yellow-legs, dowitchers, and avocets; shore birds like sandpipers and killdeer.

The habits of these birds vary with individual species, but they all feed mostly on insects, crustaceans, frogs, and other water life. A visit to pond, lake, stream, or reservoir, morning or evening during the spring migration is sure to reward the visitor with the sight of many of these birds.

The children may compare the different groups of water birds as to their structural adaptations. For example, a duck may be compared with a boat and a loon with a submarine. The duck's body is more flattened with a broader breastbone than that of the loon. The loon is more cone shaped.

The duck's legs are placed in a good position for paddling. They are short, with webbed feet. The loon's feet are far back and aid the bird in pushing off for flight or swimming under water.

Duck's beaks are scoop-like with strainers in them that strain out

the water and mud and retain the insects. Loons have pointed fishing beaks.

Penguins are similar to loons but are able to walk rather than fly. Their modified wings are used as paddles when they swim.

Though closely related to ducks, geese have beaks and legs which enable them to get food on land. If possible, children should visit a pond, lake, or stream where these birds may be seen. Zoos and museums have examples, also, which may be used to illustrate types. The importance of any of this material is to help children interpret their own environments and contribute to their understanding of the biological principle of survival.

VIII. THE VALUE OF AIR TO MAN (Pages 251–283)

Events like the one described in the text often start discussions and questions among children, about ways men use air. They wonder how a diving bell works.

A simple illustration of a diving bell may be made by filling a small bottle partly full of water and turning it upside down in a larger jar of water. Put a cork into the neck of the larger jar. Moving the cork up and down will cause the small bottle to bob up and down. As the pressure is changed on the surface of the water, the pressure of air in the small bottle is changed.

To demonstrate how the bell is brought to the surface, insert a bent tube into the jar and let the lower end extend under the mouth of the smaller bottle. Blow on the upper end of the tube forcing the water out of the small bottle. The bottle will come to the top of the water.

Problem A. What Are the Properties of Air? (Pages 253–259)

Most of the concepts given in this problem have been presented in a simple way in the earlier books of the series. If the children haven't had this background, teachers may develop it in the ways suggested in the manuals for the primary grades.

Children may ask how men know the depth of the atmosphere. There are several means that scientists use to determine this. One is by observing meteors. Meteors do not become visible until

they ignite. They do not ignite until they strike the atmosphere. By noting the time meteors begin to glow and measuring their speed, scientists can estimate the depth of the atmosphere to be between two and three hundred miles.

Since the density of the atmosphere decreases as we go up into it, its temperature decreases also. At between seven and eleven miles up, the temperature becomes constant. The region beyond this is called the stratosphere. The temperature of the stratosphere is very low and there is no convection. Children often ask questions about the stratosphere because of the attempted flights into and through it.

Suggested Activities:

In Book V, How and Why Experiments, the properties of carbon dioxide and oxygen were demonstrated. See the manual for that book for directions of simple ways to prepare and test these gases in the schoolroom.

A simple way to illustrate oxidation is to prepare some iron filings by filing a nail. Sprinkle the inside of a wet jar with the iron filings. Turn the jar upside down in a dish of water and leave for a few days. The filings will rust, or oxidize. As the oxygen is used from the inside of the jar, the decreased air pressure causes the water to be pushed up into the jar. This demonstrates the fact that some of the air has been used. By quickly putting the jar over a lighted candle, the children will discover that no oxygen remains. They should check this by repeating with a jar of the same size that has not had the oxygen removed. The jar with no oxygen should extinguish the candle immediately while in the other jar the candle will slowly go out as oxygen is used.

To demonstrate that oxygen is used in burning, stand a burning candle in a dish of water. Turn a jar over the candle. As the candle uses the oxygen and goes out, water will be forced into the jar. The children may also notice moisture being deposited on the inside of the jar. Water is the oxide of hydrogen produced when fuel burns. Fuels contain two elements, carbon and hydrogen, which unite with oxygen.

The children should perform the experiments given on pages 256–259. A simpler way to show that air has weight is to use two

toy balloons. Balance them on the two ends of a stick that is suspended from a nail by a string. Blow up one balloon and fasten it in exactly the same place it was before being blown up. The experiment on page 256 may also be done with balloons if basketballs are not available. Delicate scales are needed to weigh air.

A simple way to demonstrate that air supports things is to drop two sheets of paper, one edgewise and one with the flat surface horizontal. Drop them from the same height at the same time. Repeat, crumpling one piece of paper into a ball and having the other with the flat surface horizontal. Be sure that the pieces of paper are the same size.

The experiment on page 259 is very spectacular if done with a larger can like an oil can. Care should be taken that no one is burned. After the can is crumpled, it may be restored to its original shape by putting it on the stove again until the steam has blown it up. If a suction pump is available, the same experiment may be done by pumping the air out of the can. The normal air pressure on the outside of the can crumples it. It may then be pumped up again.

Problem B. How Does Man Use Air? (Pages 259–283)

Through their experiences children know that animals need air to live. To demonstrate that plants need air, turn a good-sized jar over a plant growing in a flowerpot. Seal the crack around the bottom with paraffin or gummed tape. Leave for a week or more. Another demonstration may be prepared by sprouting some seeds in some moist sawdust in the bottom of a fruit jar. Be sure the lid is sealed. In both experiments have a control set up under exactly the same conditions except for the factor of air supply.

To demonstrate that air carries odors, spray perfume into the air at varying distances from the class and note how quickly the children smell it. Open a bottle of spirits of ammonia and ask the children to indicate when they smell it. Ammonia is a gas that is dissolved in the liquid and vaporizes quickly. Then turn on a fan and spray some perfume in front of the fan. Note the difference in the speeds with which quiet air and moving air carry odors.

The industrial uses of air may be illustrated with simple windmills, wind chargers, and other wind-driven machines that are used in the community. Most sixth-graders will be familiar with these.

A simple pump may be constructed by children, using any kind of a pipe for the cylinder. The piston may be cut from wood, cork, or a potato to fit the inside of the cylinder. Pieces of leather or rubber may be used for the valves. If the lower end of the cylinder is placed in a pail of water and the piston pushed up and down with a stick that is fastened to it, water may be drawn into the cylinder. The diagrams on page 263 will help in the construction of the pump. If a real pump can be obtained and examined, it will help demonstrate the principle involved. Tire pumps are easily obtained.

To demonstrate the principle of a caisson, submerge a milk bottle in water and invert it. Insert a tube under the mouth of the bottle and blow air into the bottle with a bicycle pump. The compressed air will push the water out of the bottle.

When iron ore is reduced with a blowpipe, air is used in the blowpipe. By concentrating a stream of air on the flame, it makes a much hotter flame. The picture on page 267 shows a commercial blowtorch in use.

Teachers may obtain simple booklets from the various automobile factories explaining the structure and mechanics of cars. While sixth-graders do not drive cars, they are very much interested in how they work and should have their questions answered. Knowledge of the principles back of engines, gears, and brakes will make children more intelligent drivers when they are old enough to operate cars.

Many automobile factories have large wall charts which they will give or loan teachers. Often children bring old car parts from home. Junk yards are good sources of engine parts that help explain how a piston or carburetor works. If the high school has a shop with an engine for demonstration, arrangements may be made to see it. If children become familiar with the main parts of a car at the time when they are first interested, it will help them when they are old enough to drive.

A visit to an airport is the best activity to help explain how an airplane works. If this isn't possible, model airplanes and pictures

will help demonstrate the principles involved. Sixth-grade boys usually have plenty of these made in their leisure time.

Since any machine that goes up into the air is overcoming gravity, it has to be pushed up in some way. Air is the pusher and wind is a very important aid in aviation. Early airplanes could not rise without wind to help them. Modern planes overcome the absence of wind in various ways, one being a long runway. The propeller literally bores its way into the air and creates a difference in pressure that lifts the plane. By experimenting with kites, toy balloons, gliders, and airplanes, children will realize how important air is in this use man has made of it.

In constructing a siphon it is easier for the children to understand if a bent glass instead of rubber tube is used. Directions for bending glass tubing are given elsewhere in the Manual. Of course a rubber hose is the practical siphon to use in siphoning gasoline from a car or water from tubs.

Another application of the principle of water flowing from a higher to a lower level is made when water is carried across mountains by aqueducts.

Preliminary to doing the experiments shown on page 282 the children may do a simple experiment with the straw or glass tube. Put the tube in a glass of water over a bit of sand. Put a finger over the opposite end of the tube and lift it from the water. The water will stay in the tube and the sand come up with it. When the finger is removed, the water and sand drop.

To summarize the problems on air, the class may have an air show and demonstrate ways that man uses air. An orchestra composed of wind instruments might furnish music. Some of the references in the bibliography have many simple experiments not given in this book or manual.

IX. WATER ON THE EARTH (Pages 284–299)

This topic may grow out of experiences with weather, with pumps, with solutions, with health, or with other activities. A water shortage in the community, dust storms, or floods raise problems in which sixth-graders may participate. This topic is closely integrated with social studies.

One group became interested in water when a big dam was being built near their town. It raised questions of "Why do men build dams?", "How will building a dam change the climate?", and other questions the children heard discussed at home.

Another group became interested in water through hearing their parents discuss the diversion of some of the water from a large mountain lake on the west side of the Rocky Mountains to the eastern side of the mountains. These children lived in an irrigated section to which water meant everything. They were much surprised to learn that most of the water that was being diverted across the mountains had been wasted before the project was put in operation. It had run off the western slope into rivers flowing toward the Pacific Ocean.

Another group lived in an area which was frequently flooded. At these times, in spite of all the water, pure drinking water became a problem.

Problem A. How Do We Obtain Water to Use? (Pages 285–293)

The children should investigate sources of water in the community. They may list all the ways in which they use water. Filter some of the water used by the community to see if there is any sediment. Evaporate some to see if it contains minerals. Investigate the possible contamination with bacteria.

If water comes from a city water supply, a visit may be made to the source to learn how the water is obtained and purified.

If water comes from local wells, the children should study the position of the well in relation to possible sources of contamination. They may make diagrams of their own homes with the wells and barns similar to the one on page 289.

If the children belong to organizations such as Scouts or Campfire, they may have learned how to obtain pure drinking water when camping. This should be discussed in connection with this problem. Children should learn a few simple rules such as;

1. Never drink from a stream unless you *know* that there are no people living between you and the source. Only snowfed moun-

tain streams, protected from contamination by law, would fit this requirement.

2. Never drink from springs or wells that have buildings above them.

3. Boil water from these sources before drinking, or where tested water is not available, carry drinking water with you.

The demonstration on page 288 works on the same principles as the siphon. Both air pressure and gravity are at work.

The filter on page 290 will be more effective if a layer of finely crushed charcoal is placed between the sand and gravel. Since some disease-producing organisms will pass through a filter, even filtered water may not be safe to drink. For this reason most cities add chlorine to the water to kill these organisms.

In regions where water is hard, the children may try various soaps with it to see which ones are most effective. They may add soda or borax to the water to see what effect they have as softeners. They may test the incrustation deposited on the bottom of teakettles with HCl, to discover that it is calcium carbonate.

If the apparatus shown on page 293 isn't available, a teakettle with a small spout may be used by fitting a bent tube on the spout with a cork. The end of the tube may be put into a milk bottle that is standing in snow or cold water.

Problem B. How Does Water Change the Earth's Surface? (Pages 294–299)

In the earlier books in this series, the children have studied erosion on a small scale. This problem gives them a picture of the surface of the United States as it has been eroded through the last geological era.

If possible, the group should visit regions where water erosion has taken place. If soil erosion is taking place because of improper land use, the children should discuss why this is happening. They should suggest ways to stop erosion.

One group observed what had happened to a farm near town during a driving rain. The farmer had a crop of winter wheat just about four inches high. The highway ran past his field, which

sloped toward the ditch beside the road. After the rain, most of the field was in the ditch and across the road. The children studied the situation and decided that contour plowing and planting would have prevented the destruction.

The U. S. Department of Agriculture has numerous helpful bulletins, charts, maps, and pictures which will be sent free upon request. See bibliography.

A collection of clippings and pictures relating to the use and work of water may be mounted in a big scrapbook as a summarizing activity for this chapter. Models of different types of soil conservation plans may be constructed.

Teachers may carry out as many activities as seem practical and needed to make this problem pertinent to their communities.

X. MAGNETIC AND ELECTRICAL ENERGY (Pages 300–322)

In the study of water the children will learn that one way man uses water is as a source of power. They may visit a power plant and see how the big turbines are turned by water. The questions sixth-graders ask about electricity are often quite complicated. If the teacher will let them try to find the answers to these questions, she will probably be able to lead them to realize that they first have to understand some of the simpler concepts concerning electricity.

For example, the members of one sixth grade who thought they knew a great deal wanted to know how a telephone worked. When they started to solve that problem, they discovered that they didn't know anything about electromagnets. They also had to know something about induction coils and the way electricity travels. By starting with the problem of how a telephone works, the teacher led them by analysis of the problem, back to the basic concepts on electricity. She knew that this would happen, but by allowing the children to take the initiative, she kept their interest. Had she merely told them to study the simpler concepts first, much of the value to the children would have been lost.

Problem A. How Do We Use Electromagnets? (Pages 301–309)

The simple electromagnet for which directions are given on page 301 should be made and tested for the poles with a bar magnet. Use a soft iron core to make a temporary magnet. Then replace the soft iron with steel and show that a permanent magnet is made.

These electromagnets made with a dry cell are not strong enough to do any work. When a stronger one is needed, electricity from a power plant is used.

Boys enjoy making telegraph sets and trying to send each other messages. Sometimes old telegraph keys may be obtained from the telegraph company to compare with the homemade ones.

A simple knife switch may be made like the diagram at the bottom of page 305. It may be used in all the experiments with wiring bells, lights, or other circuits the children may set up. Different types of switches may be bought at the ten-cent stores to take apart and examine.

Bells and buzzers use electromagnets. The children should take one apart and find the electromagnets. They should attach the bell to a dry cell and make it ring. They should learn what causes a short circuit by doing the demonstration suggested by the diagram at the top of page 307.

Telephone companies have series of charts which may be obtained free, showing the parts of a telephone. Usually they will give teachers an old receiver and transmitter. These may be taken apart so the children can see the way they work.

The magnets in the receiver are strong enough to hold the diaphragm in place. The magnetism is strengthened when they become electromagnets. When an alternating current of electricity such as that which comes into houses, flows over the wires in the coils, the poles of the magnets are reversed. This leads to vibrations of the diaphragm which correspond to the vibrations of the diaphragm in the sending transmitter.

Problem B. How Is Electricity Generated? (Pages 310–317)

Any two metals placed in an acid solution will start a flow of electrons through the solution. The farther apart the metals are in

the electromotive series, the more electricity is generated. It is difficult to understand *what* electricity is. We know how it is generated, how it behaves, and how to use it. Physicists have theories about electricity but for our purposes in helping children answer their questions, the explanation given on pages 310–312 will prove helpful. In fact several groups of sixth-graders after reading, experimenting, and further searching for an answer to their question, "What is electricity?" have come to the conclusion, "Scientists know some things about it, but have yet to find a complete answer."

The simplest way to demonstrate a wet cell is with a lemon or grapefruit, a piece of copper, and a piece of zinc. See the manual for Book V for directions. The cell described on page 312 should be made by the teacher as sulphuric acid is very active and will cause a bad burn if spilled on skin or clothing. Be sure to pour the *acid* into the *water*, not the water into the acid. The acid reacts with water to produce heat. If the water is poured into the acid there is danger of an explosion. If the cell is properly made, the current generated will ring a bell.

Perhaps the most important part of this unit concerns safety measures. The teacher of one group impressed upon them the importance of being careful with electrical appliances by telling of an experience. One morning she found that a fuse had been burned out in her apartment. Investigating the cause, she found a dead mouse near an extension cord. A pile of fuzz from the insulation told the story. The mouse had gnawed through the insulation and had been electrocuted while short circuiting the current through its body. She put it as a problem to the group, "What happened to the mouse?" Everyone has had some experience which offers a problem situation to challenge thinking on the part of children.

Examine different types of insulation and plugs. Discuss the advantages of good over poor insulation. Cheap fixtures sometimes have the wires so close to the sides of the socket that if screws get loose the wires touch the metal sides of the socket and cause a short circuit.

Examine fuses and a fuse box to understand how they protect the circuit. Caution children against replacing fuses with any-

thing but fuses of the correct amperage. The newest kind of fuse is like a knife switch that opens and breaks the circuit when too great a load is carried over the wires.

Electricity is measured by volts, amperes, ohms, and watts. A volt is the unit of measure for pressure. An ampere is the unit of measure for current. An ohm is the unit of measure for resistance. The watt is the unit we pay for. It is the number of amperes times the number of volts.

Although some electricity is generated in wet cells, such as those used in cars, it is not practical for use on a large scale. Homes in rural areas or isolated mountain districts use storage batteries for the current generated by wind chargers or engines. Since batteries produce only direct current, the appliances used in these homes have to be fitted for DC. Dry cells are more common. In both wet and dry cells it is the chemical reaction which sets up the stream of electrons known as electricity. In the dry cell, zinc and carbon are the two elements used. Between these is a paste containing ammonium chloride. The children can take a dry cell to pieces and find these parts. They may compare them to the parts of their wet cell. A battery consists of several wet cells in a container.

Electricity for use in cities is generated in power plants. The generator transforms mechanical energy into electrical energy. It does this by cutting magnetic fields with coils of copper wire. This is alternating current.

The children can make a simple generator by using a large horseshoe magnet which is fastened to a wooden block. If a coil of insulated copper wire is rotated rapidly between the poles of the magnet, a slight current will be set up—not very much, but enough to affect a compass needle.

A motor is very similar to a dynamo. Examine a toy motor and it will be found to consist of the same parts as a dynamo. By rotating the armature rapidly, a motor will produce a current. When a motor runs, it uses electricity to produce motion. It works like a dynamo in reverse.

If the class can visit a power plant and actually see dynamos in operation, they will understand electricity much better.

Some of the children may have the toy motor sets that are on

the market. Some of these contain all of the materials needed for the construction of a motor. However, they have to be assembled so accurately that the average sixth-grader may not be able to make one work. This may be used as a class problem, with different suggestions being tried. Sometimes the dry cells are too weak to turn the motor and need to be supplemented with stronger ones.

Problem C. How Does Electricity Work for Us? (Pages 318–322)

The principle back of all electrical heating devices is that resistance to flow produces heat. We all know that a dry wooden structure burns when struck by lightning. Wood is a poor conductor of electricity. It offers so much resistance that it becomes hot enough to burn. A live tree struck by lightning may be scorched and not burn. The sap conducts the electricity to the ground because it contains much water and water is a good conductor.

Metals are much better conductors than wood, but some metals are better conductors than others. Iron wire isn't so good a conductor as copper. Thus in the experiment on page 318 the iron wire will get much hotter than the copper. The piece of iron wire should be very fine, such as one strand from a picture wire.

In lights, filaments are made of highly resistant materials. Most ordinary electric light bulbs today have tungsten filaments, but scientists are continually perfecting new types of bulbs. Fluorescent bulbs, so commonly used now, are constructed and operate in a different way from these other bulbs. The inside of the bulb is coated with something like phosphorous, a substance which glows when activated by light. Wires lead to the bulb and away from it but do not make a circuit inside the bulb. The bulb is filled with a mercury vapor, which acts as a conductor, completing the circuit. The mercury vapor is heated enough by the current to emit ultra-violet rays. These rays cause the phosphor to give off visible light.

Children may examine different types of light bulbs. A local

electrician may be willing to come to school and tell the class about modern lighting.

Questions about why all Christmas tree lights on a string go out when one goes out will be answered by the diagrams on page 322. Let the children connect several dry cells in series and in parallel to discover the way lights are connected.

The study of electricity may be summarized by allowing the group to be responsible for doing some wiring, as for example, wiring a miniature stage or doll house. Of course the teacher will need to check very carefully and be sure it is done correctly. For miniature towns, doll house, or stage where tiny bulbs are used, a transformer will have to be used to reduce the voltage to the amount needed for the bulbs used.

XI. WATER LIFE (Pages 323–354)

This unit grew out of a need for reading material to answer the numerous questions asked by children concerning water life.

Warm spring days usually find boys and girls who can find any kind of pond or puddle, wading or fishing. What adult doesn't remember the hours he spent fishing for "crawdads" in lieu of better catch? Or watching the creatures that crawled in the sandy bed of the brook or skated on the pond's surface?

The chapter should not be used to teach a mass of technical facts concerning the animals mentioned. Rather it should be used to summarize the principle of interdependence as illustrated in a typical lake or pond.

When a boy brings a jar of pond water containing eggs, insect larvae, or any other animal life, the incident may be used to set up problems. The teacher may motivate an interest by numerous methods. She may bring some water from a garden pool, a watering tank for horses or cattle, or a roadside ditch. Any stagnant water that is allowed to stand a few days usually shows evidence of life.

One teacher found fairy shrimp in rain water left in potholes on the top of a mountain. Knowing that the rocks had been dry the year before, she was intrigued by the problem of how the tiny

crustaceans got there. She showed them to her sixth-grade class, telling the story of how she had found the animals. At once the children asked "How did the fairy shrimp get there?" Some suggested that birds carried the eggs on their feet or that the wind carried them. The animals were kept alive and studied. The children read pages 336 and 337. Then they said, "Since the eggs stay in the mud all winter, these just hatched this spring." "But," the teacher objected, "last year was so dry that there was no water in the holes, so no fairy shrimp were there to lay the eggs." Since it was a problem to her, also, she was eager to find a solution. With the help of the children and a student assistant she carried out some experiments which lasted over a period of two years. The children were so interested that they came back to observe the experiments after they had left the sixth grade. By putting into rain water dry soil from potholes where there was no water, fairy shrimp were produced. Some dry mud from a pond, that had stood on a laboratory shelf for six years, also produced fairy shrimp. The eggs were isolated, hatched, and grown in rain water. However, if more water was added to the original, the fairy shrimp died. The results of the experiment showed that the eggs may remain dormant in dry mud for at least six years; how much longer is not known but would be an interesting problem to investigate.

This experience is given to illustrate the fact that an interested teacher stimulates interest in her students. It is not important that children learn these facts, but the attitudes and thinking skills that are developed through solving an absorbing problem are worth while. The "simplicity to wonder," if kept alive, may make life much richer and increase one's capacity for happiness. This chapter suggests many interesting leisure time activities or hobbies.

Suggested Activities:

Any body of water from a ditch to a large lake will serve as the laboratory for solving problems concerning water life. The class should visit as many of these places as are available. Each place should be studied for its size, location, shape, and types of life.

Tin cans, jars, and nets should be taken on these trips to collect material for further study. A net can be made from a hoop of

stout wire fastened to a piece of a bamboo fishing rod. To the hoop, sew a stout bag of loose-weave canvas or muslin.

Use the net to skim the surface of the water to capture water striders and other surface insects. It may be used to dip out floating eggs of frogs, toads, or insects. Skimming the top of the mud along the bottom will often bring up insect larvae, worms, and other interesting specimens. Dump the mud on the shore and spread it out with sticks. The animals will squirm to the surface and can be transferred to jars of pond water.

Put all animals captured into jars of water from the pond. Take only as many as you need for study. Be sure to note what kind of habitat each came from.

When back in the schoolroom the children may construct maps or diagrams of their pond, similar to the one shown on pages 324–325. Examine the water after it has settled and you may find many small creatures you didn't know you caught. If a microscope is available, the number of animals seen will be much increased.

Collect only as many frog, toad, or salamander eggs as you wish to care for. Keep them in some of the pond water with algae to provide oxygen for the developing tadpoles. The tadpoles will feed on the algae after hatching. As tadpoles grow older they will eat bits of meat and hard-boiled egg.

Dragon-fly nymphs may be kept in some of the pond water in an aquarium providing there are enough other insect larvae in the water to feed them. They will afford an excellent example of animals feeding on smaller animals. Both dragon- and damsel-fly nymphs demonstrate the wonderful transformation in insect metamorphosis. Some of the nymphs are extremely ugly and ferocious looking while the adults are among our most beautiful insects. Some nymphs are found in the mud of the pond, some clinging to stems of water plants.

Mosquito larvae should be kept in a covered aquarium so they will not escape when transformed. If you have a large aquarium, it would be very instructive to have the mosquitoes and dragon flies in the same aquarium.

Caddis-fly nymphs are found crawling along the bed of a brook or in other shallow water. Their cases are made of bits of sand, sticks, leaves, or other particles found in the stream. They look like

little chimneys moving along. Although they thrive best in moving water, caddis-fly larvae may be kept alive for a while in an aquarium which has enough microscopic life for their food.

True bugs belong to the order Hemiptera and are easily recognized by the pattern on their backs formed by the overlapping wings. This pattern is easily seen in the pictures on pages 334–335. Water bugs are very interesting to watch. Some of them capture a bubble of air and carry it under the water as a sort of oxygen tank. It makes the bug look silvery. With this bubble the bug is able to stay under water a long time. All water insects possess interesting breathing devices.

Many minute crustaceans are to be found in the pond, some microscopic in size. Cyclops are visible as tiny dots darting through the water. Examined through a microscope, a cyclops shows the large single eye which gives the group its name. Another interesting thing about cyclops is shown in the picture on page 335. The females carry their eggs in two egg sacs which look like extra tails. When examined under a microscope, the internal structure of these creatures can be seen.

Water fleas range in size from visible to microscopic forms. Viewed through the microscope, they show their relationship to crayfish. One class while watching some water fleas were startled to see still tinier ones emerging from under the carapace of one flea. Upon investigating a book on water life, the class discovered that this variety of water flea carries its eggs in brood pouches until they hatch.

If you have tropical fish to feed, a culture of water fleas (Daphnia) is easily established in the spring. Put pond water and algae into the aquarium and remove any insects which might feed upon the Daphnia. Dragon-fly and water-bug nymphs will destroy water fleas. From time to time add more pond water to supply food for the Daphnia.

The eggs of fairy shrimp may dry up and live through unfavorable conditions to hatch some time later when water again appears. Fairy shrimp vary in size but may be as large as the picture on page 336. Children sometimes find them and think that they are "baby" crayfish. They are beautiful and interesting crustaceans.

Crayfish are more commonly called "crawdads" by youngsters and adults. They are closely related to shrimp and are used for food in some places. They are easily kept in an aquarium and fed on bread or bits of meat. They are scavengers and feed upon all kinds of dead animals, as well as smaller water animals.

Clams make good scavengers in an aquarium but should be returned to the pond or lake after a few days as they don't live long out of their natural habitat.

Live clams may be found in the shallow water of lakes and rivers, or along ocean shores. If they have been moving, their path will be marked by a trail in the mud or sand. They move slowly by contracting and extending the fleshy foot which they protrude from the anterior end of the shell. When at rest clams are often completely buried except for the siphons at the posterior ends of their bodies. When picked up, a clam closes suddenly, squirting water from the exhalent siphon.

Clams and snails are mollusks. Clams are bivalves and snails are univalves. The shells of some snails twist in a left-handed direction and some in a right-handed. In both, the shell is made by a secretion from the mantle which hardens. (See limestone unit in HOW AND WHY DISCOVERIES.)

Some snails lay eggs in masses of gelatinous material that is deposited on leaves or stems of plants. Other snails brood the eggs within the mantle cavity and the little snails are born alive. Snails in an aquarium often attach their eggs to the sides of the aquarium. The development of the eggs may be watched through a hand lens or microscope.

The slimy slugs that leave their silvery trails along the garden path, or are found among the lettuce or cabbage leaves, are snails with very small shells. The shell is so small as to merely shield the animal's back.

Turtles are easily kept in an aquarium which has sand built up at one end to allow the turtles to come out of water. They may be fed on small bits of hamburger which seem to appeal to the turtle more if a trifle spoiled.

As hobbies, many children have fish in home aquaria. If no body of water is available that is stocked with fish, a pet shop aquarium, zoo, or park may afford a place to see live fish. Fish are as beauti-

ful as birds when seen from the side. We do not realize this because we usually look down at the dorsal edge.

The habits of fish are very interesting. Children often have questions on how fish can go up and down so fast in the water, if fish sleep, and how they breathe.

Teachers should attempt to bring out the characteristics of these water animals which make possible their life in the water. The flattened body of the fish, its scales, its lack of neck, its pointed head and fins all help propel the fish. Its gills by which it breathes and air bladder by which it moves up and down are other interesting modifications of structure.

Pond plants possess interesting modifications. Although living in water, it is often difficult for them to get water. This is because water plants, like land plants, absorb water through their roots. The roots are often in much colder places than the leaves. The rate of evaporation from the leaves would exceed absorption by the roots were it not for the thick leaves. Thick leaves, waxy surfaces, and other structures help prevent evaporation in these water plants. Cross sections of cat-tail and water-lily stems will show air spaces that also help these plants to survive. If a microscope is available, some of the pond water will probably reveal microscopic green plants, the algae. Algae are important factors in the balance of pond life since they furnish food for smaller animals. These animals in turn feed larger animals. A food chain might be made from man to algae something like this: Man—fish—smaller fish—water fleas—algae. Algae manufacture their own food just as larger green plants do. They release oxygen in the process of food making, thus helping to maintain a balance of gases in a pond.

Though birds do not actually live in the water, they are an important factor in the relationships in and around a pond. If the teacher can take the class on a field trip to observe water birds during spring migration, they may see birds that are foreign to the region. For example, pelicans are often seen around irrigation reservoirs on the western plains. Flocks of plovers, sandpipers, and other waders are often there in great numbers. Dawn and sunset are the best times to observe birds, but during migration some are sure to be seen at any time.

The outcomes learned in this chapter may be summarized by making and balancing a large aquarium, or a pool in the school garden. The class may give a program and demonstrate the way to make and balance different types of aquaria. They may tell how to care for the plants and animals suitable for an aquarium. Children who live near the ocean, a gulf, or a large inland lake should study the life in that body of water and make comparisons with that of a smaller body of water. Members of the same plant and animal families are to be found near and in all bodies of water.

XII. COMMUNITY HEALTH (Pages 355–374)

This is a good subject to use toward the end of the sixth grade to gather up many threads of learning in science and social studies. It may be introduced by a study of the health of the community. The children may visit the city health nurse or officer and get a report on the number of cases of communicable diseases which have occurred during the year.

Problem A. How Are Diseases Spread? (Pages 355–367)

Cultures of potato, gelantin, or agar may be made and sterilized. Let some flies and other insects walk across the sterile media. Incubate and compare with unopened sterile plates.

The material on insects in the first part of the book will give the children background for an understanding of the life histories of these insects. Some diseases, like malarial fever and Rocky Mountain spotted fever, are communicated to man only after an incubation period in the bodies of certain insects or their relatives.

If teaching in a region where tick-borne diseases are common, teachers should familiarize themselves with the habits of wood ticks. Wood ticks are more nearly related to spiders than insects, and are carriers to man only during certain stages of their development. A great deal of work on spotted fever has been done at the agricultural experiment station in Bozeman, Montana, and the U. S. Public Health Service and Montana State Board of Entomology, Hamilton, Montana. Bulletins may be obtained from both

of these places. They also have films depicting the life history of ticks which may be obtained free by communities or large groups, by paying transportation.

As knowledge of bacterial diseases increases, more methods for combating them are being discovered. The attention is turning to diseases which have other causes. Some of these, like colds and influenza, take large tolls every year because of their after-effects. People are urged to treat the common cold as a disease to be taken care of at once. This is where teachers can cooperate and teach children how to avoid getting and spreading the disease. The Metropolitan Life Insurance Company has a good bulletin on colds and influenza.

If no health nurse is employed in the school, daily inspection of throat and eyes by the teacher will usually catch the first signs of colds and many other children's diseases. Red eyes and throats may show the presence of infection before sneezing or running noses appear. If possible, these children should be sent home to bed. At least they should be isolated from the rest of the group and kept warm and quiet. Each time a case of infection is present in school the teacher and children should discuss the cause, symptoms, ways of preventing, spread, and cure.

Many children who may appear clean do not know how to be sanitary. Habits of washing the hands *before* eating, *after* going to the toilet, *after* blowing the nose, and *before* handling food should be instilled in children from babyhood. Merely dipping the hands into water does not cleanse them. To effectively remove any micro-organisms, they must be washed thoroughly in warm water and soap. To impress this fact, prepare gelatin or agar culture plates. Have the children touch one with unwashed hands, another with hands dipped in cold water, and a third with hands *scrubbed* with soap and warm water. Incubate all three alike and examine results. Several children should perform all three tests—the larger the number doing it, the more accurate the results. Children infect themselves from their own unwashed hands—as do many adults who have never formed sanitary habits. The teacher may contribute a great deal to the future health of the community by drilling the children in good health habits. Children should discuss and know *why* these habits are important.

Sixth-graders may be interested in separating into groups and studying different diseases. Group research, if not carried to the point of play, is valuable. Reading material is not available on many common diseases, such as cancer, diabetes, and sleeping sickness. Yet for some reason, a child may want to know about one of them. The teacher may rewrite material for him to read or ask the health nurse or a doctor to answer the child's questions. Some magazine articles and health bulletins may be read by sixth-graders with a little help. They may also look through material to find pertinent facts. One class period can profitably be spent locating reading material on a problem. If supervised, it teaches a language skill.

Problem B. What Has Science Done to Prevent the Spread of Disease? (Pages 368–374)

The different groups may choose to study the lives and work of such men as Walter Reed and Robert Koch. Some of the work being done on carriers of sleeping sickness, infantile paralysis, and spinal meningitis may be investigated and reported upon.

The Health Service of the Cleanliness Institute of New York City has some excellent publications which are free to school administrators or other health workers. These have good suggestions for activities children may carry out to help prevent the spread of disease.

Material may also be obtained through local and state Boards of Health and from the U. S. Bureau of Publications at Washington.

Since vitamins were discovered, interest in them has grown until all sorts of vitamin pills are on the market. In many drugstores vitamin pills and capsules are as common as patent medicines used to be. Of course, foods are the best source of vitamins as well as the cheapest source. In cases where an individual is unable for some reason to eat these foods, he may have to use substitutes. But children should be taught to use pills only on the advice of their physician. One of the most important scientific attitudes for children to gain is a critical attitude toward advertisements.

All through this problem stress should be placed on those diseases common to the community. A case of athlete's foot, a sore

throat, or any other infection should be discussed and treated properly. Since methods of treatment are constantly changing, the nurse or doctor should do this. If any insect-carriers of disease are common in the community, some of them should be obtained and a study made of their life cycles. Different methods of killing the insects may be tried on live insects and the most effective method discussed.

Wood ticks are becoming more common in many parts of the United States. There are several varieties, each carrying a specific disease. Teachers should find out if they are common in their regions. If so, send for bulletins on ticks. Collect a few ticks in a jar and familiarize yourself and children with the appearance of the pest. Usually a dog which has been in tick-infested areas will have many ticks clinging to it. They resemble dog ticks, but are found only for several months in the spring. When hot, dry weather comes, the ticks disappear. The bulletins suggested give pictures and information concerning prevention of the diseases.

The problem may be culminated by an assembly program. There are many health pageants that the teacher can buy, but most groups prefer to prepare their own programs. Scenes from the lives of great scientists who have contributed to the control of disease may be dramatized.

Moving pictures like the lives of Pasteur and Erhlich have aroused popular interest in this subject. Many children have seen these pictures. They will suggest scenes the children might re-enact.

In small schools or in rural areas a campaign against flies, mosquitoes, or other disease-carriers would be a good summarizing activity. Efforts to obtain sanitary drinking and washing facilities might be a problem in a rural school. A wholesome milk supply might be a problem in another school. The children may visit the sources of food supply of various kinds and rate them according to a simple rating sheet.

The Companion Book for How and Why Discoveries includes activities to carry out in the study of health.

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A KEY TO THE COMPANION BOOK

p. 1—*The Food of Animals*

Some examples are:

Cat: mice; tearing teeth; hunting

Squirrel: nuts; gnawing teeth; from the ground when they are fallen

Cow: grass; grinding teeth; with hard, upper jawbone, lower incisors, and tongue

Hog: roots; grinding teeth; digging in the ground for roots

Bat: insects; sharp, pointed teeth; sweeping the air

Cardinal: seeds; thick beak; picking seeds from a sunflower head and cracking them

Blackbird: caterpillars; sharp, pointed beaks; in its beak from leaves of plant

Duck: water insects; flat, scoop-like bills; straining out water and mud

Humming bird: nectar; long, slender beak; sucking nectar from flowers

Kingfisher: fish; pointed beak; diving into water for fish

Garter snake: insects; small, curved teeth; catches insect in open mouth

Snapping turtle: crayfish; sharp, strong jaws; snaps at food

Lizard: insects; long, sticky tongue; raises itself on its hind legs and darts quickly

Frog: insects; sticky tongue; flops out its tongue and catches the insect

Salamander: insects; sticky tongue; catches insect on tongue

Bass: small fish; strong teeth; holds its prey with its teeth

1. All have ways to get food.
2. All eat food to obtain energy.

p. 2—*Are Rodents Helpful or Harmful?*

1. *a.* Beavers should be protected.

b. Unless they occur in large numbers, they should not be killed.
c. Where they are harming farmer's crops, they should be killed; otherwise they should be allowed to live.
d. Since they are not harmful, they should be allowed to live.

p. 3—*Are Rodents Helpful or Harmful?* (continued)

2. *a.* The man-made dam is constructed of concrete, earth, and steel; the beaver-made dam, of sticks and mud.
   b. The man-made dam is opened by a gate. It is straight. The beaver-made dam is continuous—it may zig-zag back and forth.
   c. The man-made dam is controlled; the beaver-made dam may cause floods.
3. Water that is held behind a dam drops some of its load of sediment before flowing down the river.

p. 4—*Some Ruminants*

1. *a.* They crop the grass close to the ground. They act as lawn mowers.
   b. They eat the bark and also rub it off with their horns.
2. *a.* Skull
   b. Skull
   c. The deer's horns grow and are shed each year. Cattle do not lose their horns. Deer's horns are branched; cattle's horns are not.

p. 5—*The Teeth of Mammals*

1. horse: grain, grass
2. anteater: insects from ground
3. hog: grain, insect larvae
4. goat: grass
5. mouse: grain, other plant food
6. seal: meat (fish)
7. tiger: meat
8. skunk: meat (insects)

p. 6—*The Sources of Our Meals*

1st column: P, P, P, A, A, A, P, A; A, P, A, P, M, P
2nd column: P, P, P, P, P, M, P, P, P, A, P, P, P, M, P, P
3rd column: P, A, P, P, P, P, A, A, P, A, A, A, M, P, A, P

p. 7—*The Value of Birds*

Some examples are:

1. *a.* thrush, ovenbird, warbler, woodpecker
   b. song sparrow, catbird, thrasher
   c. meadow lark, bobolink
   d. oriole, bluebird, robin
   e. duck, bittern, sandpiper, red-winged blackbird
   f. wren, catbird, cardinal, martin

2.

	Desirable Birds	*Undesirable Birds*
Chicken farmer:	barn owl	Cooper's hawk
	wren	sharp-shinned hawk
Fruit farmer:	warbler	robin
	thrush	magpie
Grower of flower seeds:	humming bird	horned lark
	swallow	sparrow
Grain farmer:	screech owl	crow
	red-tailed hawk	pheasant

p. 8—*Is a Crow More Helpful Than Harmful?*

1. No.
2. The small amount of grain they eat is more than overbalanced by the harmful insects they eat.

p. 9—*Is a Crow More Helpful Than Harmful?* (continued)

1. Individual chart.
2. No.
3. Most of the things they eat are harmful to man.

p. 10—*Reptiles and Amphibians*

Horned toad: reptile Garden toad: amphibian

Ways alike: Both bury themselves in the ground; have four legs; eat insects; are the color of their surroundings.

Ways different: The horned toad has scales; has claws; the young resemble adults; lives in dry places. The garden toad has a smooth skin; has no claws; the young do not resemble their parents; lives in wet places.

Lizard: reptile Salamander: amphibian

Ways alike: Both have long, slender bodies with tails; have four legs; eat insects.

Ways different: The lizard is covered with scales; has claws; the young resemble their parents; lives in dry places. The salamander has a smooth skin; has no claws; the young do not resemble their parents; lives in wet places.

p. 11—*The Importance of Fish*

Yellow perch: 1, 2, 3, 4.
Whitefish: 5, possibly other fish.
Stickleback: larvae of 1, 6.
Trout: 1, 2, 3, 4, 5.
Sucker: possibly 5.
Black bass: possibly other fish.
Sunfish: 1, 2, 3, 4.
Minnow: 1, 2, 3, 4, 5, 6, 7.
Bullhead: 1, 2, 3, 4, 5, 6, 7.

Insects 1 and 7 would probably be found near the surface.
Insect 4 would be near the middle.
Insects 2, 3, 5, and 6 would be near the bottom.

p. 12—*Feeding Habits of Fish*

Surface Feeders: sunfish, trout, bass, whitefish
Bottom Feeders: carp, sucker, sculpin
Those Which Feed in Middle of Stream: mackerel, cod, herring, stickleback, bullhead

p. 13—*Insects and Their Control*

Upper half of page: 1 and 2. Individual answers.

Lower half of page:

1. contact
2. poison
3. poison (bran mash)
4. poison
5. poison
6. poison
7. contact
8. contact

p. 14—*Do You Know?*

1. would grow so long that the rodent would be unable to eat
2. like hands, to hold their food

3. in the first part of its stomach
4. cud
5. their tongues
6. at night while in flight
7. sticky fluid on its tongue
8. wings, beak, and feet
9. those that eat mice, rats, insects, and seeds from weeds; also liquid-feeding birds (in cross-pollination)
10. fly with their mouths open and scoop in insects from the air
11. saw-toothed edges of their beaks act as strainers
12. sap
13. pushes its bill into the heart of the flower and sucks up the nectar
14. the regurgitated bones and fur of animals eaten by hawks and owls

p. 15—*Do You Know?* (continued)

15. in wading in water and spearing fish
16. Their jaws become unhinged and their muscles stretch.
17. to force the food back into its throat
18. used to paralyze or kill prey
19. in poison glands
20. with its sharp jaws
21. when they become adults
22. because it is attached to the front of the mouth
23. to help push the food into its mouth
24. shape of body, fins
25. smell, sight, touch
26. from solid to liquid food
27. paralyzes the insect and sucks up the body juices
28. with a sticky substance
29. near the hinge

p. 16—*Some Problems*

1. Many insects on the bushes would fall into the water, furnishing food for fish.
2. Put snails, tadpoles, or other algae into the aquarium.
3. Most of the non-poisonous snakes are helpful because they eat insects and rodents. These should not be killed.

4. No. Hawks that eat chickens do not soar watching for their prey, but sit on a hidden branch and dart down unobserved.

p. 17—*A Test*

Flesh-eating: tiger, cat, bear, dog, snake, owl, water turtle, hawk, lion, kingfisher

Plant-eating: deer, snail, goat, earthworm, sheep, land turtle, hog, rabbit, horse, porcupine, duck, rat, squirrel, canary, goose

Seed-eating: sparrow, horse, duck, squirrel, canary, cardinal, goose

Insect-eating: spider, horned toad, blackbird, bat, snake, swallow, owl, water turtle, hawk, warbler, anteater, duck, woodpecker, goose

pp. 18–19—*The Systems of the Human Body*

See pages 37, 40, 44, 45 of How and Why Discoveries.

p. 21—*How Energy Is Produced*

The answers going clockwise on page are:

1. Food is eaten. (done)
2. Food is chewed. The starch is partly digested and swallowed. The protein is digested in the stomach.
3. The dissolved food goes into the intestines. (done)
4. The dissolved food is carried by blood to all parts of the body.
5. Food goes into the cells. (done)
6. Energy is released. (done)
5. Oxygen and food combine in the cells. (done)
4. Blood reaches all parts of the body. Oxygen goes into the cells.
3. Blood circulates. (done)
2. Oxygen passes through the walls of the lungs.
1. Air goes into the lungs. (done)

p. 22—*How Animals Breathe*

Fish	Water (done)	Through gills near its head (done)
Dog	Land	Through lungs

Chicken	Land	Through lungs
Turtle	Land and water	Through lungs (does not breathe under water)
Frog	Land	Through lungs
Tadpole	Water	Through gills
Grasshopper	Land	Through spiracles
Clam	Water	Through gills
Crayfish	Water	Through gills
Pond Snail	Water	Through gills or lungs
Spider	Land	Through sac-like lung (called lung book) in abdomen
Earthworm	Moist earth	Through the skin
Human Being	Land	Through lungs

p. 23—*Expressing Ideas in Different Ways*

Lines from:	1. to C	4. to B	7. to F
	2. to D	5. to E	8. to H
	3. to A	6. to G	9. to I

p. 24—*Cells*

Drawings—Obvious.

The Skin

1. Protects the body from the entrance of bacteria. (done)
2. Protects the body from injury by registering pain, heat, and cold.
3. Protects the body by regulating temperature and lubricating the skin.

p. 25—*How Flowers Grow*

1. Obvious
2. Obvious

p. 26—*Some Ways in Which Sounds Are Made*

Object	*Sound*	*Object*	*Sound*
teakettle	whistling	bird	singing
corn popper	popping	person using a chopping bowl	chopping
chimes on wall	chiming	knives	rubbing

Object	*Sound*	*Object*	*Sound*
radio	talking, musical	coffee percolator	bubbling
alarm clock	ringing	toaster	ticking
faucet	of rushing water	food mixer	whirring

p. 27—*Solving a Problem About Sound*

A. Check: 1, 2, 5, 7, 8, 9.

B.

Page	*Number of experiment on the page*
64	Whole experiment
65	Whole experiment
66	No. 2
69	No. 1 and 2

C. Grooves are made in a record by a needle that is caused to vibrate at different rates by sound waves. When the record is played the needle of the phonograph transforms these vibrations back into sound waves.

p. 28—*How Sound Is Used to Measure Distance*

1. 6,600 2. 4,400 3. 2,200

p. 29—*Musical Instruments*

A. 1, 8, 13
B. 2, 3, 4, 5, 6, 7, 10, 12, 15
C. 8
D. 3, 9, 11, 14

p. 30—*Developing a Scientific Attitude*

Check: 1. *c;* 2. *d;* 3. *c.*

p. 31—*How Far Away Are the Stars?*

1. 4,566,210 years

2.

Betelgeuse	114,155,251 years
North Star	28,538,813 years
Regulus	34,246,575 years
Pollux	18,264,840 years
Antares	228,310,500 years
Deneb	399,543,375 years
Altair	9,132,420 years
Vega	14,840,183 years

3. 240,000,000,000,000 miles

4. *a.* 1041⅔ miles *b.* about 347 miles *c.* 10–15 miles

p. 32—*How Far Away Are the Stars?* (continued)

5. *a.* $7\frac{3}{11}$ *b.* $63\frac{7}{11}$ *c.* 20

The Characteristics of a Star

1. Check: e, f.

2. p. 87: Our sun is one great big star in this big system. Our sun, the stars we see, and the Milky Way are all a part of our galaxy.

   p. 88: Our sun is a star because it shines by its own light. The sun is really only a medium-sized star. Yet to us it looks very large. That is because it is nearer than any other star.

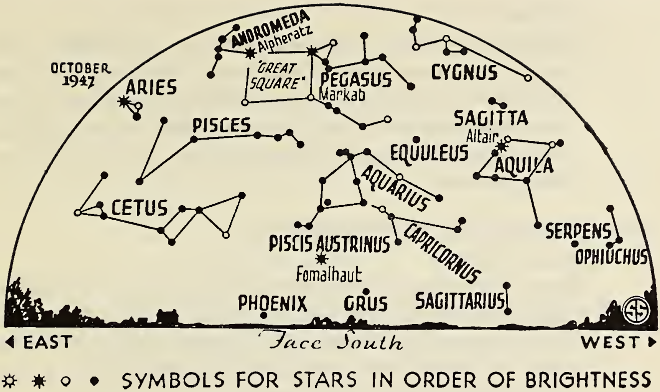
   p. 91: The sun is only a medium-sized star. The sun is very important to the earth because it supplies the earth with heat and light.

   p. 92: Stars shine by their own light.

   p. 94: The sun is a yellow star. Its temperature on the surface is thought to be about 11,000 degrees.

pp. 33–34—*Constellations*

Individual answers. See star maps such as those reproduced below and on the next page from *Science News Letter*.



p. 35—*Time Zones*

1. about 1041⅔ miles
2. about 3½ seconds
3. *a.* 11:00 A.M. *b.* 9:00 A.M. *c.* 8:00 A.M.

p. 36—*Other Planets*

Individual answers including any of the characteristics given on pages 110–119 of HOW AND WHY DISCOVERIES.

p. 37—*The Moon*

Individual drawings. Any reasonable drawing that shows characteristics of the moon.

p. 38—*Tides*

1. Individual drawings.
2. Any with which the pupil is familiar. Some examples are: starfish, clams, scallops, snails, crabs, abalones, oysters (in rocky places), whelks, sea urchins, sandworms, sea dollars, sea cucumbers.

p. 39—*Comets*

If the earth's path is represented by a circle with a radius of 1⅛ inches, with the sun as a center, small circles on this path can be drawn to represent the earth as it comes near the comet's path, crosses it, and moves on.

Telescopes

Individual answers. Some examples are: the nature and paths of comets, planets that cannot be seen with the naked eye, materials composing the sun, character of the moon nebulae and other galaxies, more about meteors, diameter of the planets, distances of the stars and planets from the sun.

p. 40—*Comparing Some Heavenly Bodies*

Planets: (done)

Moons: revolving around planets; spiral or oval; by reflected light; smaller than the planets around which they revolve

Stars: in space beyond our solar system; through space; by their own light; from a little larger than the earth to many, many times the size of the sun

Meteors: in space within our solar system; oval path around the sun; heat caused by friction when they strike the atmosphere; from the size of grains of dust to several tons

Comets: in space revolving around sun; an elongated oval; energy from the sun; head may be as large as a planet

p. 41—*A Review of the Steps in Problem Solving*

Problem: How could a 200-inch glass mirror be made without having it crack in cooling?

Possible answers: It might be cooled slowly by using an electric cooling system. It might be made of a special kind of glass.

What the scientists did to test their possible answers: They made a mold that looked something like a huge pie tin. To cover the mold they made an oven that looked something like a beehive. They poured molten glass into the mold. They sealed the giant mirror in the beehive to cool. They reduced the temperature slightly each day.

Results—what happened? After the mirror had cooled gradually for twenty-one months, it was taken out of the oven uncracked.

Conclusions—what they learned: A 200-inch glass mirror can be made of special glass in twenty-one months by using an electric cooling system.

p. 42—*The Importance of Calcium Carbonate in Our Lives*

1. The shell will react and bubbles appear.
   It is soft.
   Calcium carbonate
2. *a.* It will effervesce if it is calcium carbonate.
   b. It will effervesce if it is made of shell.
   c. It will effervesce if the acid penetrates to the calcium carbonate.
   d. Acid touching dentine will react at once; acid touching enamel will react slowly.

p. 43—*The Importance of Calcium Carbonate in Our Lives* (cont.)

2. *e.* The inside should effervesce.
   The outside should not react unless it is polished.
3. It may be pliable.
   Pliability would be the result of calcium carbonate reacting and dissolving.
   Calcium carbonate
4. It should become milky.
   It should become clear again.
   Calcium carbonate
5. It should effervesce.
   With dilute acid
   With dilute acid

p. 44—*Caves*

1. Individual drawings for 2, 3, 5, 6
1. As rain comes through the air, the gases in the air dissolve in the rain water and make a weak acid.
2. The weak acid, seeping down, down, down, reaches the limestone layer, dissolves it little by little, and carries it away.
3. As the cave grows larger, the water continues to drop from the ceiling.
4. This builds the stalactites.
5. The water that doesn't evaporate here drops to the floor to evaporate and leaves its load of calcium carbonate.
6. Thus spires are built bit by bit until sometimes the stalagmites growing up meet the stalactites growing down.

p. 45—*Caves* (continued)

2. Individual drawings.
3. As water drops, it spreads out on the floor of the cave.
4. The water evaporates, leaving calcium carbonate.
5. It looks double.
6. (1) shell conglomerate
   (2) chalk (containing flint)
   (3) marble
   (4) marl
   (5) calcite
   (6) limestone fossil
   (7) lithographic limestone
7. All of them contain calcium carbonate.
8. *a.* It would effervesce.
   b. It contains calcium carbonate.

p. 46—*Types of Limestone*

Chalk: famous chalk cliffs of England; from one-celled animals in the sea; blackboard chalk, cleaning powder

Marl: lake beds, shores of bodies of water, bottom of the sea; from plants containing calcium carbonate; making Portland cement

Shell conglomerate: bottom of the sea (one place is in Florida); from shells and skeletons of sea animals which sank to the bottom; building material

Lithographic limestone: limestone layers in rock that was once under water; from fine particles of calcium which settled to the bottom of a body of water; making lithographs

Fossil-bearing limestone: wherever limestone layers are found; from shells and skeletons in the bottom of bodies of water; by scientists to learn more about prehistoric life

Calcite: in hollow pieces of limestone and caves; calcium carbonate crystallizing; no commercial use, but beautiful in rock gardens or rock collections

Iceland spar: in hollow pieces of limestone and caves; calcium carbonate crystallizing; in optical instruments

p. 48—*Calcium in Our Diets*

1. Check: milk—whole; cheese—American; orange—whole; cabbage; tomato.

2–3. Individual answers.

p. 49—*The Importance of Glass*

Individual answers. Some examples are: window, electric light, glass in door, milk bottle, aquarium, prism, compass, camera, eye glasses, vase, clock, coffee pot, tumbler, pitcher, thermometer, glass over picture.

p. 50—*Identifying Minerals*

I. (done)

II. 1. Calcium carbonate
- *a.* Calcite
- *b.* Marble

III. (done)

p. 51—*Identifying Minerals* (continued)

IV. 1. *b.* Rock crystal
- *c.* Amethyst

2. *a.* Jasper
- *b.* Flint
- *c.* Chert
- *d.* Chalcedony
- *e.* Carnelian
- *f.* Agate

1. chert
2. graphite

p. 52—*The Importance of Ores*

Individual coloring and keys based on list.

p. 53—*A Review of Rocks and Minerals*

Write	*Cross out*
3. stalactites	3. *lithographs*
6. crystals	6. *bubbles*
7. calcite	7. *chalk*
8. shell	8. *pebble*
9. oyster	9. *crayfish*
10. lime	10. *iron*
11. cottage cheese (or any food containing lime)	11. *candy*
15. glass	15. *diamond*
16. ultra-violet	16. *infra-red*
17. curved	17. *straight*

p. 54—*A Review of Rocks and Minerals* (continued)

Write	*Cross Out*
21. smelted	21. *soaked*
24. zinc	24. *copper*
26. harder	26. *softer*
27. oxygen	27. *hydrogen*
30. iron	30. *gold*
31. sulphuric	31. *hydrochloric*
34. carbon	34. *oxygen*
35. red	35. *white*
37. liver (or any food containing iron)	37. *cake*
38. live	38. *eat*

p. 55—*Convection Currents*

Bonfire: Arrows coming from the sides and pointing under the fire.
Arrows going up from the top of the fire.

Forest fire: Same as 1.

Desert: Arrows pointing down the mountain. Arrows pointing upwards from the desert.

Lake: Arrows as on p. 170 of HOW AND WHY DISCOVERIES.

p. 56—*Types of Precipitation*

1. rain 2. hail 3. snow 4. sleet

p. 57—*The Movement of Highs and Lows*

Individual coloring based on outlines on maps.

p. 58—*Changes in Air Movements From Day to Night*

Day	*Night*
1. Arrows pointing down the mountain to the valley, then over the valley to the mountain.	1. Arrows pointing from the valley up the mountain. then to the valley.
2. Arrows pointing from the lake to the land, then over the land to the lake.	2. Arrows pointing from the land to the lake, then over the lake to the land.

Day	*Night*
3. Arrows pointing from the oasis to the desert, then over the desert.	3. Arrows pointing from the desert to the oasis, then over oasis to the desert.
4. Arrows pointing from the river to the wheat fields on both sides of the river, then over fields to the river.	4. Arrows pointing from the wheat fields to the river, then over the river to the wheat fields.

p. 59—*The Use of Clouds in Forecasting Weather*

1. Obvious
2. Cirro-stratus
3. Alto-stratus or nimbus
4. Strato-cumulus, cumulus
5. Fair weather

p. 60—*Cyclones and Tornadoes*

Tornado: The wind would blow in small whirls, not more than 300 feet wide.

Signs: rapidly falling barometer, funnel-shaped cloud; violent, twisting wind; noise of wind.

Cyclone: The wind would blow in huge whirls, many miles wide.

Signs: falling barometer; cloudy sky; warm air.

Individual drawings showing a person going into a cellar or lying flat on the ground away from building.

p. 61—*Different Kinds of Winds and Their Causes*

1. convection
2. It is heavier than warm air and gravity pulls it more.
3. wind
4. land
5. toward the land
6. cumulo-nimbus
7. warm
8. low
9. less
10. storm
11. center
12. cyclone
13. warm
14. anti-cyclone (or high pressure)
15. cools it
16. rotation of the earth from west to east
17. 1,000 miles; 300 feet or less
18. black, funnel-shaped cloud

19. the suction caused by unequal pressure
20. typhoon
21. They are moving air.
22. They carry moisture-laden clouds, thus making rain, snow, and other precipitation.

p. 62—*The Use of a Barometer*

Monday: (done)

Tuesday: 9:00; 29.56; 29.96	Thursday: 9.00; 29.52; 29.92
Wednesday: 9.00; 29.52; 29.92	Friday: 9:00; 29.3; 29.7

p. 63—*A Review of Weather Forecasting*

Individual answers. Some examples are: falling barometer, cumulus clouds, unseasonably warm air, still air.

p. 64—*How to Interpret a Weather Map*

Map: obvious.

Temperature: thermometer.	Air pressure: barometer.
Precipitation: rain gauge.	Wind velocity: anemometer.

p. 65—*Weather Sayings and Proverbs*

Check: 1, 2, 4, 5.

Some examples are:

1. Cirrus clouds are formed by rapidly moving air as a cold front moves under warm, moist air.
2. This may happen but it is not always true, especially in a dry region.
   (In 3, the saying arises because the sunlight is reflected from dust particles in air or water droplets evaporated and condensed around dust in the air.)
4. There is some truth in this.
5. Same as 4.

p. 66—*Weather Sayings and Proverbs* (continued)

Check: 7, 8, 10, 11, 12, 14.

Some examples are:

7. Cirrus clouds show that warm air was in contact with cold air. Precipitation may follow.
8. Moisture is precipitated by cool air.
10. Fog is formed when evaporating moisture is cooled near the earth.
11. Wind in front of a low comes from the east. When the direction of the wind changes to the west, the low is passing over the area.
12. Fading stars mean a cloudy sky.
    (13 is not true. Certain high points are struck again and again.)
14. Since a tree often is the highest point in an area, the tree carries electrons up its trunk and branches. This creates pressure or tension.

p. 67—*A Summary*

Individual answers.

p. 68—*A Summary* (continued)

Individual answers.

Word Meanings

Lines between:

1. —Big, billowy clouds, dome-shaped on top and flat on the bottom.
2. —Violent, whirling wind
3. —Thick, dark clouds with ragged edges that hang low.
4. —Straight clouds that hang low in the sky.
5. —Raindrops frozen into tiny drops of ice.
6. —Records temperature.
7. —Low-pressure area.
8. —Instrument used to record speed of wind.
9. —Instrument used for measuring and recording the amount of moisture in the air.
10. —Used to record air pressure.
11. —High-pressure area.
12. —Instrument that measures amount of moisture that falls.

13. —Clouds that make a "mackerel" sky.
14. —Feathery clouds high in the sky.
15. —Shows direction wind is flowing.
16. —Thunder clouds.
17. —Moisture in the air.

p. 69—*Edible Wild Plants and Animals*

Individual answers. Any menu containing the foods needed for a balanced diet.

p. 70—*The Effects of Narcotics*

See pages 193–198 of How and Why Discoveries.

p. 71—*The Spread of Contagious Diseases*

An example is: The father carries some of the diphtheria bacteria in his throat. He is immune so he doesn't get the disease. As he bottles the milk, he coughs or sneezes. Some bacteria get into the milk or on the bottles or caps. People who are not immune to diphtheria drink the milk and get the disease.

Public Health Agencies

Some examples are:

1. Milk is pasteurized.
2. Cows are tested for tuberculosis.
3. People are given the tuberculin test.
4. Tubercular patients are treated at sanitariums.
5. Tubercular patients are kept in bed and fed wholesome food.
6. Organizations care for children of tubercular parents.
7. Part of the funds received from the sale of Christmas seals is set aside for research.
8. Scientists are doing research work to find new cures.
9. Tuberculosis clinics X-ray people.

p. 72—*Causes and Cures of Common Diseases*

Diphtheria: (done)

Smallpox: virus; human beings; vaccine

Lockjaw: bacteria (from horse manure); rusty nails or other sharp, rusty instruments; lockjaw antitoxin

Typhoid fever: bacteria; contaminated water or food; typhoid vaccine, pure water and food

Tuberculosis: bacteria; human beings, milk; wholesome food, fresh air, rest, sunshine

Blood poisoning: bacteria; objects that make wounds; new drugs, proper care of wounds

Colds: virus; human beings; staying away from people when you have a cold, keeping your body strong

Whooping cough: virus; human beings; whooping cough vaccine

Athlete's foot: fungus; shoes, wet floors around swimming pools and showers used by many people; cleanliness, careful drying of feet, not walking barefooted where other people having the disease might have walked

Ringworm: fungus; clothing such as caps; avoid wearing other people's clothing

p. 73—*Health Terms*

1. antitoxin serum
2. narcotic
3. fungi
4. nicotine
5. athlete's foot
6. caffein
7. naturally immune
8. X-ray
9. antibodies
10. blood poisoning
11. protozoa
12. tuberculin test
13. anesthesia
14. sulfa derivatives
15. local anesthesia
16. viruses
17. unprescribed medicines

p. 74—*How Some Animals Care for Their Young*

Human being: (done)

Dog: born alive; three to ten; for a few weeks

Robin: hatch from eggs; four; for a few weeks

Duck: hatch from eggs; eight to twenty-four; for a few weeks

Turtle: hatch from eggs; two to several dozen; no care

Horned lizard: hatch from eggs; twelve or more; none

Frogs: hatch from eggs; several thousand; no care

Codfish: hatch from eggs; many thousands; no care

Snails: hatch from eggs or are born alive; numerous; no care

Crayfish: hatch from eggs; 200 or more; no care, even though they cling to their mothers
Mosquito: hatch from eggs; 40 to 400; no care
Moth: hatch from eggs; several hundred; no care
Spider: hatch from eggs: several hundred; no care
Blanks at bottom of page: life; reproduces

p. 75—*Migration and Hibernation*

Individual answers.

p. 76—*National Parks*

Individual answers.

p. 77—*Helping With the Program of Conservation*

Any answers that are reasonable such as:

1. rabbit, dog	6. screech owl	11. ground squirrel
2. rabbit, quail	7. flying squirrel	12. flicker
3. pheasant	8. coyote	13. heron
4. skunk, crow	9. muskrat	14. porcupine
5. flicker, hawk	10. deer	15. gull

p. 78—*Helping With the Program of Conservation* (continued)

Individual maps.

p. 79—*Helping With the Program of Conservation* (continued)

Individual answers.

p. 80—*Helping With the Program of Conservation* (continued)

Individual drawings.

p. 81—*Survival or Extinction*

Some examples are:

Flicker: (done)

Snakes: 1, 3. cold-blooded; temperature changes
1. hibernates
5. shape; scales

Frogs: 1. hibernates
4. tongue attached to front of jaw
5. slimy secretion; color

Dogs: 1. heavy coat of hair

Beavers:
1. fur
4. gnawing teeth
5. makes its home on water

Deer:
1. heavy coat of hair
3. migrates to higher places
5. color

Bears:
1. hibernates; stores fat
2. sheds some of its fur
5. sharp claws and teeth

Tile-fish:
1. migrates
4. teeth; shape of mouth
5. shape of body; scales

Chicken:
1. feathers
4. eats seeds, etc.
5. protects its young

3. sheds part of heavy coat of hair
4. long, sharp canine teeth

Grass-hopper:
1. eggs laid in ground
4. chews pieces from leaves
5. color

Field mice:
1. partial hibernation
4. gnaws plants
5. color

Monarch butterfly:
1. migrates
4. nectar
5. color, flight

Codfish:
1. hibernates
4. feeds on other fish
5. moves swiftly

Lions:
1. hibernates
4. long, sharp canine teeth
5. teeth; claws

p. 82—*Survival or Extinction* (continued)

B. Any answers that are reasonable such as:

Passenger pigeon: Hunters killed them in large numbers. Some of the young died after the parents were killed. Forests, which furnished the birds with their chief supply of food, were destroyed.

Great auk: Fishermen raided the nesting grounds for eggs. Hunters killed them in large numbers.

Heath hen: Hunters killed them in large numbers.

C. Any answers that are reasonable such as:

Buffalo: Large numbers were killed after the railroads were built westward across the United States. Early settlers cultivated the grazing lands.

Egret: Many were killed for their feathers. The young egrets starved in their nests.

Wild turkey: Hunters killed many males and females. Many of the young died because the adults could not care for them.

Seal: Hunters killed both males and females. No offspring could be raised after the female was killed.

p. 83—*Recognizing Scientific Attitudes*

Some examples are:

Page 21: (done)

Page 34: You probably will be able to see the burrows that the earthworms have made. 5, 6

Page 35: Maybe there is something in the pork and egg that the soldiers need. 5, 6

Page 36: I'd like to know what to believe. 5, 6

p. 84—*Recognizing Scientific Attitudes* (continued)

Page 48: Have you ever seen the slogan, "Have you had your iron today?" 6

Page 63: "Now, Mr. Thorne," said Bob, "could any of these stories be true?" 6

Pages 70–71: Whole pages. 3

Page 93: Whole page. 5

Page 113: Whole page. 5

Page 118: Whole page. 3

Page 132: Whole page. 1

Page 133: What is a meteor? Where does it come from? At least you will not call it a shooting star. You know that stars are too far away. 1

Page 169: Because weather changes are important to him, man tries to tell in advance what changes will occur. 2
Page 181: Whole page. 1
Page 182: Whole second paragraph. 4
Page 205: Whole page. 1
Page 206: The microscope revealed a new world to scientists. 7
Page 209: Whole second paragraph. 3
Page 217: He experimented on animals. 5
Page 231: Whole first paragraph. 3
Page 271: Whole page. 2
Page 284: "I'm going to find out something about it." 6
Page 300: Whole page. 2
Page 311: Whole page. 7
Pages 319–321: From the third paragraph on page 319 through the ninth line on page 321. 3
Page 356: Whole page. 7
Page 358: Whole first two paragraphs. 3, 6
Page 364: Whole first paragraph. 2

p. 85—*Four Groups of Water Birds*

Kind of beaks: pointed, fishing beaks; flat, scooping beak; pointed, fishing beak; pointed, fishing beak
Kind of legs and feet: long legs with long, strong toes; short legs with webbed feet; short legs with small, webbed feet; short legs placed far back with webbed feet
Shape of body: streamline; boat-shaped; streamline; cone-shaped, like a submarine
Kind of feathers: not so thick as other water birds; thick down with well-oiled outer feathers; strong, wing feathers with down not quite so thick as on ducks; thick down with outer feathers well oiled
Type of young: helpless, naked when hatched; down-covered, able to walk and swim; down-covered, soon able to walk; down-covered, able to swim as soon as dry
Birds I saw: Individual answers.

p. 86—*Protection by Color*

Individual answers.

p. 87—*A Review of Water Birds*

1. mallard ducks
2. bittern
3. herons
4. Canada geese
5. gulls
6. flamingos
7. bitterns
8. wood duck
9. terns
10. gulls
11. loons or grebes
12. gulls or terns
13. redhead
14. black-crowned night heron
15. egrets

p. 88—*A Diving Bell*

1. It floats.
   It is full of air.
2. It is partially submerged.
   The water in it makes it heavier.
3. Air.
   It goes to the bottom of the dish.
   The water was pushed out of the glass.
4. Air.
   As water runs into the bottle, air bubbles out and the bottle sinks.
5. The water is forced out of the bottle and the bottle sinks.
   As air went into the tumbler it rose; as air was sucked out of the tumbler it sank.

p. 89—*A Comparison of the Properties of Air and Water*

Pure water: (vertical) hydrogen and oxygen; liquid; solid; gas; colorless; tasteless; odorless

Air: (vertical) oxygen, carbon dioxide, nitrogen, and traces of water vapor, helium, neon; gas; gas; gas; colorless; tasteless; odorless

Blanks: 1. water
2. air
3. nitrogen, carbon, helium, neon

p. 90—*Carbon Dioxide or Calcium Carbonate?*

1. calcium carbonate
2. carbon dioxide
3. carbon dioxide
4. calcium carbonate
5. calcium carbonate
6. carbon dioxide
7. calcium carbonate
8. calcium carbonate
9. carbon dioxide
10. calcium carbonate
11. calcium carbonate
12. carbon dioxide
13. carbon dioxide
14. calcium carbonate
15. calcium carbonate
16. calcium carbonate
17. calcium carbonate
18. carbon dioxide

p. 91—*Safety Rules to Observe in Experimenting with Carbon Dioxide*

1. metal tray
2. paper
3. the fingers
4. hair; neckties
5. water
6. matches
7. burning
8. chemicals
9. adult
10. beginning it

p. 92—*Experiments with Carbon Dioxide*

Experiment I.

1. The candles are extinguished in succession.
2. *a.* CO_2 will not burn.
   b. CO_2 is heavier than air.

Experiment II.

1. The bubbles float to the ground.
2. CO_2 is heavier than air.

Experiment III.

1. It goes down.
3. The candle is extinguished.

p. 93—*Experiments with Carbon Dioxide* (continued)

Experiment IV.

1. When the candle is extinguished, the water flows into the jar.
2. The pressure in the jar was lessened.
3. oxygen
4. nitrogen and CO_2
5. $\frac{1}{5}$

Experiment V.

1. The splinter bursts into flame.
2. The steel wool bursts into flame.
3. Oxygen supports combustion.

p. 94—*Some Properties of Air*

Experiment I.

1. The end with the filled balloon goes down.
2. Air has weight.

Experiment II.

1. (It may break the stick.) It feels heavy.
2. This is caused by the weight of the air above the newspaper.
3. It is not so hard to move.
4. less
5. It becomes less.
6. The amount of air surface accounts for the difference.

p. 95—*Breathing*

1. expands
2. contracts
3. made it larger
4. made it less
5. Air from outside the balloon pushed into it.
6. lessened it
7. made it greater
8. Air was pushed out of the balloon.
9. pulls the ribs up and out
10. The ribs collapse and push the air out of the lungs.

p. 96—*A Pump*

1. It moves up.
2. As the piston moves up, it pulls air out of the cylinder. More pressure on the water pushes water into the cylinder.

An Automobile Engine

See pp. 268 and 269 of How and Why Discoveries.

p. 97—*Lighter-than-Air Craft*

Some examples are:

Experiments:

1. A balloon was filled with hot air.

2. A balloon was filled with hot air. Several bags of sand were put into the basket of the balloon and were thrown out when the balloon was up a few hundred feet.
3. Balloons were filled with hydrogen.
4. Balloons were filled with helium.
5. A balloon was built on rigid frames and shaped like a cigar. A steering device and an engine were put on a balloon.

Results:

1. The balloon rose three hundred feet.
2. When the load was lightened, the balloon could go higher.
3. The balloons rose rapidly. Some exploded.
4. The balloons did not explode.
5. The balloon's flight could be directed.

Blank lines at bottom of the page:

A bag filled with gas is used for support. This gas is lighter than air. Compartments larger than the early baskets are used to carry men.

p. 98—*Heavier-than-Air Craft*

Blank line: The paper rises.

Arrows: The arrows showing *lift* should extend from the plane upward; those showing *pressure* should be under the plane, pointing upward to the plane.

p. 99—*A Review of Air*

1. The second container should be in a lower position than the first.
3. Valve should be added.
5. Bulb should be over the tube in the atomizer.

p. 100—*Choosing Material to Help Solve Problems*

Some examples are:

Problem I. Page 88 of this Companion Book, No. 5

Problem II. Page 88 of this Companion Book, No. 2 and 5.

Problem III. Page 259 of HOW AND WHY DISCOVERIES, "Air Has Pressure."

Problem IV. Page 88 of this Companion Book, No. 1, 2, and 5

Problem V. Page 257 of How and Why Discoveries, "Air Is Elastic."

Problem VI. Page 259 of How and Why Discoveries, "Air Has Pressure."

Lines at the bottom of the page: Individual answers.

p. 101—*The Importance of Water to Plants*

Problem: How important is water to plants?

Rest of page: Individual answers.

p. 102—*The Importance of Water to Man*

Individual answers.

p. 103—*The Local Water Supply*

1–2. Individual answers.
3. Individual maps.

p. 104—*The Necessity for Pure Water*

1. no
2. bacteria
3. Boil the water before drinking it.
4. Liquid from the manure in the barnyard.
5. disease bacteria
6. individual drawings.

p. 105—*How a Filter Works*

1. It should have been clear.
2. No; it might contain disease bacteria.
3. visible dirt
4. by chlorination, aeration, boiling, distillation
5. *a.* water is put in a vat.
   b. Water seeps through sand.
   c. Water seeps through gravel.
   d. Water seeps into a chlorine solution.
   e. Water seeps out of a chlorine solution into a pipe.
   f. Water is aerated.
   g. This is the pump house where the water is pumped into pipes.
   h. Water runs through the pipes to people's homes.

p. 106—*Other Ways in Which Water May Be Purified*

1. *a.* Filter the water; then boil it.
   b. Distill the water.
   c. Filter the water.
2. *a.* (1) visible dirt
   (2) salt
   (3) soot
   b. (1) filtration
   (2) distillation
   (3) filtration
3. *a.* It evaporates.
   b. It remains behind.
   c. It condenses.
   d. They remain in the container.
   e. They do not evaporate.
   f. flat
   g. aeration
   h. Shake it or pour it from one container to another.

p. 107—*How Soil May Be Conserved*

1. Have the rows of corn run parallel with the fence in the foreground and across the hill in the background.
2. Plant wild grass on the slopes. Fill up the gully.
3. Use contour plowing. Plant slopes with grass or other vegetation that will grow there. Fix road.
4. Fill up gullies. Plant grass, shrubs, and trees.

p. 108—*Contour Plowing*

Obvious.

Some Questions About Erosion

1. The water follows the furrows; the water does not run downhill.
2. It would hold moisture in the soil, thus preventing floods.
3. They dam up streams. This makes ponds where the soil settles.

p. 109—*How Man Changes the Surface of the Earth*

Upper picture: 1. The valley was formed by the river.
2. The river changed its course.

Lower picture: 1. The course has been changed.
2. Men used machines to make the changes in the valley.

p. 110—*How Man Changes the Surface of the Earth* (continued)

1. A lake has formed where only a valley would have formed naturally.
2. Some examples are:
   the kinds of rocks in the mountain and under the valley
   the rate of stream flow
   the amount of pressure exerted by water
   the height from which the water came
   the grade of the slope below the dam
   the kind of soil available for use in the dam
   the way engines and other machines, such as pulleys, levers, and wheels work
   the chemical reaction of lime in making the proper cement
   the way pumps work
   the hardness of rock and the way to use dynamite for blasting
   the way to use electricity

p. 111—*The Principle of the Electromagnet*

Experiment 1.

1. so that electricity can pass into the wires
2. to complete the circuit
3. around the nail
4. No; the part around the wire is covered with insulation.
5. a magnet
6. It may for an instant but not any longer.
7. *a.* They move.
   b. They stand on end.

Experiment 2.

1. strengthens it

p. 112—*The Principle of the Electromagnet* (continued)

Experiment 3.

1. increases the magnetic field
2. makes the electromagnet

Experiment 4.

1. If the nail is made of steel, it will attract the tacks.

2. This will depend on the kind of nail used.
3. A steel magnet will remain magnetized for a time; the soft iron magnet will not.
   steel
4. no effect

Page 303—Experiment 1.

1. The strip of iron is attracted. It comes down with a click.
2. nothing
3. It would be permanently magnetized and there would be no click.

p. 113—*The Principle of the Electromagnet* (continued)

Page 304—Experiment 2.

1. iron or steel coated with tin
2. individual diagrams
3. scrape off the insulation
4. Diagram is not correct. Cells and instrument should be connected as at top of page 302 and middle of page 304 of How and Why Discoveries.

p. 114—*Do You Understand Wiring?*

See diagrams on pages 301–306 of text.

p. 115—*The Parts of a Telephone System*

1. (done)
2. Conducts electrical vibrations.
3. Conducts electrical current to the wires going to the central office.
4. Carries electrical vibrations to the central office.
5. Electrical vibrations transformed again to sound.
6. Changes sound to electrical current again.
7. Conducts electrical current to the receiver in your friend's home.
8. The electrical current flows around the magnet.
9. The magnet becomes stronger and weaker with electrical pulsations.
10. The diaphragm vibrates and transforms the current into sound waves.

p. 116—*Generating and Testing the Flow of Electricity*

1. a magnetic field
2. It will be attracted and move.
3. They react to the acid.
4. sour
5. chemical change

p. 117—*Safety Measures to be Used with Electricity*

1. Go into a building, or if none is near, go into the grove of trees. (A grove of trees is safer than one tall tree.)
2. Wearing rubber or dry cotton gloves, pull the man off the wire while another person holds the wire with a dry stick.
3. Disconnect the plug.
4. Cut the wire above the frayed part, remove the worn part of the wire from the plug, and put the plug on the good wire.

p. 118—*Precautions when Using Electricity*

1. He is touching an electric switch while in the water.
2. He is spraying water on electric wires.
3. He is putting a piece of metal into an open socket.
4. He is plugging a worn-out wire.

p. 119—*How Lights Are Wired*

1. in parallel
2. obvious
3. obvious
4. in series

p. 120—*Zoning in a Pond*

Individual drawings.

Some Pond Insects

1. six
2. three
3. head; abdomen
4. two
5. metamorphosis
6. skeletons

p. 121—*Some Pond Insects* (continued)

Dragon fly: incomplete; water; egg, nymph; gills; water insects; small insects such as mosquitoes

Damsel fly: incomplete; water; egg, nymph; gills; water insects; small insects such as flies and gnats

Mosquito: complete; water; egg, larva, pupa; pore at the tip of the abdomen; tiny animals and plants; male: plant juices, female: blood

Caddis fly: complete; water; egg, larva, pupa; gills; mostly insects, some plants; probably nothing

Water strider: incomplete; water; egg, nymph, adult; comes to the surface for air; mostly animal food; insects, snails, and other animals

Water boatman: incomplete; water; egg, nymph, adult; comes to the surface for air; water larvae, worms, and other animals; sediment in ponds

p. 122—*The Adaptations of Some Insects*

Pictures in order down the page: whirligig beetle, diving beetle, water strider, water bug, giant water bug

p. 123—*Crustaceans*

Water flea: (done)

Cyclops: by eggs (about 200 at a time); in water; similar to adult, but with fewer legs; chitinous outside skeleton; gills; 10

Fairy shrimp: by eggs; in mud at bottom of water; similar to adult, but with fewer legs; chitinous outside skeleton; gills on feet; varies—10 or more

1. Some examples are:
   Water flea: most of body under carapace
   Cyclops: one eye; egg sacs
   Fairy shrimp: swims on back; eggs can dry up
   Crayfish: young carried under tail of female
2. Some examples are: crab, shrimp, lobster.

p. 124—*Mollusks*

Blank lines at top of page: any eight of the following.

buttons, knife handles of mother-of-pearl, pearls from oysters, fertilizer, chicken feed, marl to make Portland cement, coral beads, marble, lithographic prints, chalk, limestone, oyster shells

Snail: coiled, one valve; with sticky foot; withdraws into shell; some used for food, they are scavengers

Oyster: two valves; young swim, then they become attached to shell; closes shell; food

Mussel: two valves; with fleshy foot; closes shell; some for food, shells used

Nautilus: coiled, one valve partitioned; moves on bottom of sea by means of tentacles; withdraws into mouth of shell; none

Squid: small, imbedded in back; swims; inky fluid called sepia; cuttle bone, sepia

Octopus: (done)

p. 125—*A Summary of the Ways in Which Animals Reproduce*

1. protozoa
2. oyster
3. snail
4. grasshopper
5. spider
6. bee
7. crayfish
8. stickleback
9. frog
10. some fish and snakes
11. turtles
12. birds
13. duck-billed platypus
14. opossum and kangaroo
15. sheep, cattle, etc.
16. dogs, cats, human beings

Blanks at bottom of page: some examples are, fewer young; young more helpless at birth; more care of young by parents.

p. 126—*Diseases—Their Causes and Treatments*

Typhoid fever: (done); (done); (done)

Tuberculosis: bacteria; cattle; pasteurization of milk

Yellow fever: (done); mosquitoes; destroying breeding places of mosquitoes, putting fish into lakes

Bubonic plague: bacteria; fleas on rats; destroy rats

Typhus: (done); lice; disinfecting clothing with DDT, dusting bodies of human beings with DDT dust

Spotted fever: (done); wood ticks; removal of tick before the tick has burrowed into the skin

Malaria fever: (done); malarial mosquito; destroying breeding places of mosquito, putting fish into lakes

Diphtheria: bacteria; human beings; examination of the throats of all people who handle food

p. 127—*Preventing the Spread of Diseases*

1. Do not suck on a sucker another person has had in his mouth.
2. Hold a handkerchief over your face when you sneeze.
3. Do not enter or leave a place that is quarantined.
4. Do not wipe your hands on a towel on which someone else has wiped his hands.

The Importance of Vitamins

1. Vitamin B_2.	Milk or leafy vegetables.
2. Vitamin C.	Citrus fruit juices.
3. Vitamin A.	Green and yellow fruits or vegetables.
4. Vitamin B_1.	Milk, lean pork, liver, lamb, or chicken.
5. Vitamin K.	Cereals, leafy vegetables, rice, bran, soybean oil, or hemp seed.
6. Vitamin D.	Fish-liver oils, liver, or eggs.

p. 128—*The Importance of Laws Regarding Handling of Food*

Some examples are:

1. Keep the barns clean, light, and airy. Screen the windows. Brush the cows and wash their bags before milking. Clean and sterilize all utensils used. See that all the milkers have medical examinations and that they have no disease. See that the milkers' clothing and hands are clean. Pasteurize the milk.
2. Screen the windows and doors of the store. Keep fresh produce clean and cool. Put perishables in a refrigerator or icebox; remove immediately all spoiled food. Exterminate all insects, rats, and mice. See that the clerks have medical examinations, and that they have no disease. See that they are clean.
3. Have the refrigerators, cutting blocks, and knives clean. Clean the grinders every day. See that the clerks and

butchers have medical examinations, and that they have no disease. See that they have clean clothing and hands.

4. Keep the produce cool. Use sprays of water to keep the produce fresh. Remove all spoiled produce immediately. See that the clerks have medical examinations and that they have no disease. See that they are clean.
5. Use modern dishwashing and refrigeration equipment. Serve only fresh, good quality food. Keep the garbage cans covered. Stress cleanliness of restaurant and employees. See that the employees have medical examinations and are free from disease.
6. Have sanitary working quarters. Can only the best quality fresh vegetables and fruits. Can the produce properly. See that the employees have medical examinations and are free from disease. See that they are clean.
7. Same as **6.**

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